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On the Risk Management of Demand Deposits and Interest Rate Margins

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Abstract

This paper deals with risk mitigation of interest rate margins related to banks demand deposits. We assume that demand deposits are linked to interest rates and business risk, which cannot be fully hedged on financial markets. The dynamics of forward market rates follows a standard market model (i.e. BGM model). The demand deposit is the monetary amount put in to account by clients. It is accounting in M1 (monetary aggregate 1). Using a linear regression, the deposit rates are related to the market rates in linear ways. We take the viewpoint of an asset and liability manager focusing on the bank's net operating income at a given quarter according to standard accounting rules. We use the static hedging strategies for bank deposit. We illustrate our results using data from 1997 - 2019 for both US and Euro zones. This allows us to illustrate and compare the hedging of the interest rate margin for these two main zones, for which the deposit rate setting are clearly different (roughly speaking, in the US zone the deposit rate is equal to about half of the interest rate while, in the Euro zone, the two rates are much closer).

1.Introduction

Financial institutions[2] are very complex organizations, offering many financial services through several departments and divisions, each with specialists to make different types of financial decisions. After the crisis, it was decided in April 2009 that it was necessary to address the inadequacy of the regulatory framework in order to reduce the economic imbalance in the financial system. The various governments and prudential authorities therefore planned new programs to improve the financial system. However, particularly in the euro area, the emergence of negative interest rates has a significant impact on the banking system and in particular on the risk management of demand deposits. Demand deposits represent a prominent source of structural interest rate risk both due to their high volumes and complicated option-like behavior (clients may deposit or withdraw their money at any time without penalty and banks are allowed to change the interest rate). Without options, it would be relatively easy for banks to hedge the structural interest rate risk by matching the duration of their assets and liabilities. Banks study the behavior of demand deposits rates and volumes under different scenarios. The aim of this paper is to propose hedging strategy, which would both ensure high and stable interest rate margins (English, 2002) through time and allow for timely payments, if clients wish to withdraw their money more quickly than expected in the baseline scenario. Financial institutions must hedge bank deposits (see De Jong, Wielhouwer; 2005) in case of large interest rate fluctuations. In this paper, we focus on the demand deposits in both the Euro and the US zones, and illustrate a quadratic hedging strategy to manage interest rate margins. Monetary deposits are contractually repayable on request of the deposit holders. However, in practice clients keep these balances with the banks for a longer period. The customer's deposit rate is often well below interbank rates (especially for many current accounts). For some demand deposits (savings accounts, current accounts), the rate may change at the bank's discretion without any direct link to market rates (i.e. they have a so called managed or administrated rate).

Unmatured deposits are an important source of funds and profits for banks. The amount of these deposits is fairly stable. It is accounted for in the M1 aggregate by Central Banks. These amounts are usually reinvested by banks on treasury markets or directly in customer loans (with a margin over treasury market rates). The profit generated by these deposits at the end of the accounting year is the product of the cumulative amount of deposits multiplied by the difference between the cash market rates less the usually lower interest rate paid to the client. Thus, profits can represent a large part of banks' profits. Indeed, deposit remuneration schemes can take different forms. The remuneration policy influences the behavioral models of clients, and therefore the valuation of deposits (see e.g. Laurent, 2004, Frauendorfer and Schurle, 2003). In Jarrow's modeling framework, interest rate sensitivity of aggregate balances was subject to theoretical and empirical studies (see e.g. Selvagio 1996; Jarrow and Van Devanter, 1998; Janosi *et al.*, 1999; O'Brien, 2000; Damel, 2001; Frachot, 2001). This paper deals with the hedging[3] of the quarterly net interest income of deposits using FRAs (Forward Rate Agreements). The European Commission endorsed in November 2007 the IAS 39 (Bahaji, 2009). Fair Value Option Amendment and two carve-outs, allowing hedging strategies that lead to a smooth income associated with bank deposits. In the United States, there is still some uncertainty about the accounting treatment of assets and liabilities (see, Adam *et al.*, 2012). It is likely that the pending approach based on interest paid and received will continue for some time. For bank

[2]I thank Prof. Joël PETEY, for helpful comments. I grateful Prof Jean-Luc Prigent to as well, for his contribution to the ideas developed in this paper.

deposits, quantitative information includes the increase (decrease) in profits or the economic value of upward and downward rate shocks, depending on the management's method of measuring the Interest Rate Risk in the Banking Book (IRRBB).

This paper focuses on the financial hedge of the net interest margin, defined as the income generated by the investment of demand deposit amounts on interbank markets while paying a deposit rate to customers. Our contribution is to analyze the interest rate margin of a quadratic hedging strategy (see Schweizer, 1991; Prigent, 1999) which is an important issue for a bank. Additionally, we illustrate and compare this hedging strategy of the interest rate margin (Saunders and Schumacher, 2000) for two main zones, namely the Euro and US zones for which the deposit rate settings are clearly different (in the US zone the deposit rate is equal to about half of the interest rate while, in the Euro zone, the two rates are much closer).

This paper is organized as follows. In section 2, we provide the main statistical properties of demand deposits both in the Euro and US zones, while recalling some characteristics of Euribor and Libor rates during the last decade. Section 3 illustrates the hedging issue of the margin interest rate by examining the quadratic hedging strategy in the static case for bank deposits. Finally, section 4 concludes.

2. Statistical properties of demand deposits and interest rates in the European and US zones

2.1 Demand deposits

In July 2002, a draft regulation was implemented by the European Commission to require listed institutions to adopt IFRS accounting standards that advocate a valuation method based on the fair value principle. Within this framework, the IAS 39 devoted to hedge accounting is based on accounting methods (macro-hedge versus micro-hedge). For this purpose, the proposal to revise the hedge accounting component has been sent to the International Accounting Standards Board (IASB) by the European Banking Federation (EBF). They support an accounting treatment for the macro-hedging practices of European banks. We consider the macro-hedge that is performed by asset-liability managers of European banks which allows reducing capital volatility. The macro-hedge is announced as the most flexible approach and the least expensive. Studies also show that it is the best overall understanding of the risk and the modeling of risk. For IAS 39, which is a micro-hedge meeting international accounting standards, it is suggested to use derivative products on interest rates. The demand deposits are proxied M1 in the period from September 1997 to July 2019. They measure the amount of money circulating in economy, usually presented as end-of-month values expressed in domestic currency. In France for example, the structure of household deposits is strongly influenced by regulated savings products (such as Livret A, PEL). On average, in nominal terms deposit amounts located in France are at a higher level than in other European countries.

2.1.1 Descriptive statistics and graphic representations in the Euro zone

Figure 1 : illustrates the monthly deposit amounts issued from European (Euro) zone between January 1997 to July 2019

Table 1	Monetary Deposit in €	Variation of Monetary Deposit
Mean	1 516 105	0.5805%
St-deviation	1 201 992	2.8260%
Skewness	1.0907	355.908657%
Kurtosis	-0.06133373	3271.95333%
Maximum	4 915 465	48.7811
Minimum	131 419	17.1590

Table 1: Statistics of demand deposits in Euro zone (1997-2019)

For the statistics of monetary deposits in Euro Zone, we note that the mean of variation is about 0.58% and the standard deviation about 2.82%.

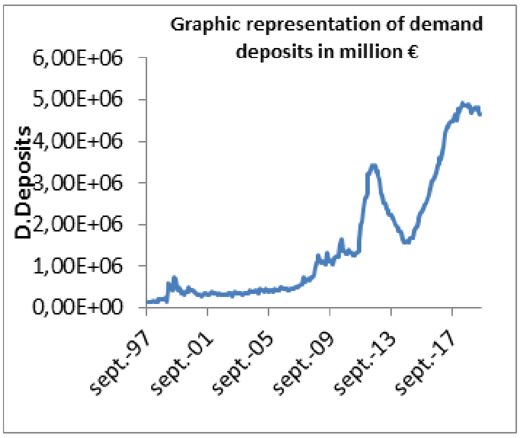

Figure (1): Demand deposit amount (monthly) in the Euro-Zone in million €.[4]

[4] **webstat.banque-france.fr**

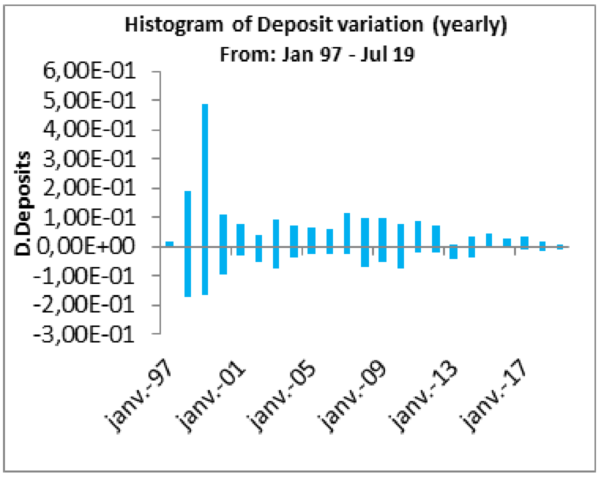

Figure (2): Rate variation of demand deposit in Euro Zone.

Figures 1-2 represent the fluctuation of demand deposit amounts and histogram of deposit variation in Euro-zone.
We considered monthly amounts issued from the Euro Zone between January 1997 to July 2019. We note that monetary deposits are stable during the period 1997-2011, then over the period 2012 to 2019 there is a fluctuation followed by an upward trend.

2.1.2 Descriptive statistics and representation graphics in the US zone

Figure 2 illustrates the monthly deposit amounts issued from European (Euro) zone between January 1997 to July 2019.

Table 2	Monetary deposits $	Variation of monetary deposits
Mean	671	0.2233%
St-deviation	391	0.7282%
Skewness	0.83569857	-181.1118%
Kurtosis	-0.96019669	1124.7437%
Max	1525	4.7223%
Min	296	-6.9619%

Table 2: statistics of demand deposits in US zone (1997-2019).

Looking at table 2 which provides the main statistics of monetary deposits in US Zone, we note that the mean of variation is about 0.22% and the standard deviation about 0.72%.

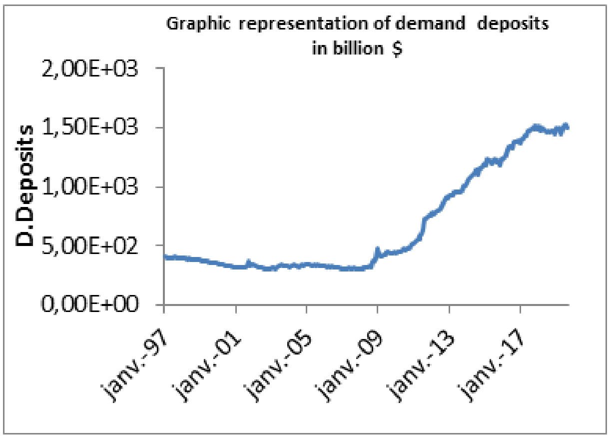

Figure (3): Demand deposit amount(monthly) in US in Billion $.[5]

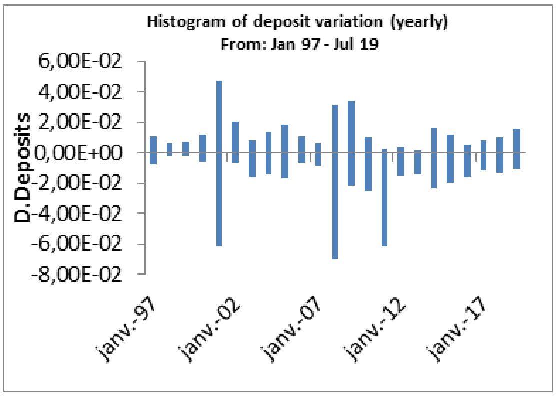

Figure (4): Rate variation of demand deposit in american zone.

Figure 3-4 illustrate the fluctuation of demand deposit and histogram of deposit variation in US.

We considered monthly amounts issued from the US zone between January 1997 to July 2019.monetary deposits are stable over the period 1997 to 2011. Then, over the period 2012 to 2019, there is a slight fluctuation in monetary deposits.

2.2 Market rate and deposit rate

From June 2014, the ECB decided to set a negative value of its deposit facility rate. This situation is perceived as an anomaly since it implies that you agree to pay for deposits. In the case of Euro zone,

[5] **fred.stlouisfed.org**

we consider monthly data of the 3M Euribor while for the US zone; we consider monthly data of the 3M Libor. We illustrate the statistical representations of the Euribor market in the Euro and US zone from January 2003 to April 2019 in basis point (bp).

Table3	Euribor 3M
Mean	132.6bp
St-deviation	133.10bp
Skewness	8481.96bp
Kurtosis	-3312.19
Maximum	529bp
Minimum	33.1bp

Table (3): Statistics of the Euribor market 3M during 2003-2019.

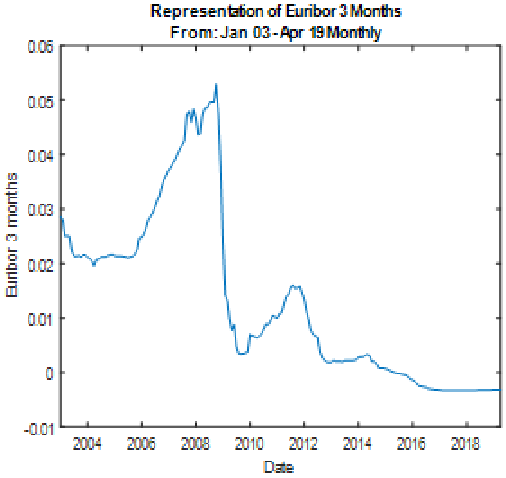

Figure (5) : Euribor market 3M(monthly).[6]

In figure 5, we observe the curve decreases significantly after 2008, but in 2010 we remark an increasing rate in the Euro zone, and in the statistics of the 3M Euribor market during 2003-2019, the mean is equal to 132 bp and the standard deviation is to 133 bp.

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[6] See www.euribor-rates.eu

Table 4	Libor 3M
Mean	169.31bp
St-deviation	138.24bp
Skewness	11146.52bp
Kurtosis	-225.6
Maximum	566.05bp
Minimum	22.3bp

Table (4): Statistics of the Libor market 3M, during 2003-2019.

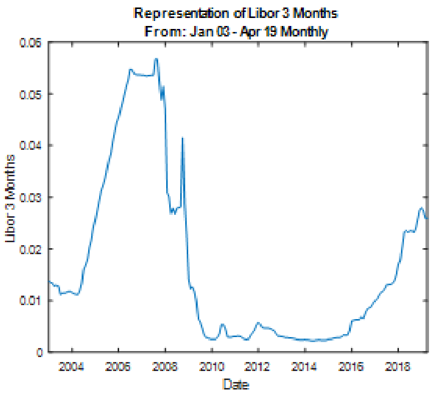

Figure (6): Libor market 3M(monthly).
Source: www.global-rates.com

In figure 6, for the 3M Libor market we note that after 2008, the curve decreases significantly, but in 2009 we observe the increase of rate and the stability of the curve in 2010-2017 and the statistics of the 3M Libor market (Andersen and Andreasen, 2000), during this period, the mean is equal to 169 bp and the standard deviation to 138 bp.

Depending on the local business model the amount of deposit account are determined from the interests served to clients. As suggested by Hutchison and Pennacchi (1996) or Jarrow and Van Deventer (1998), the deposit rate exhibits some dependence with respect to the market rate. Hutchison and Pennacchi (1996) assume the deposit rate to fulfill some affine relation with the market rate.

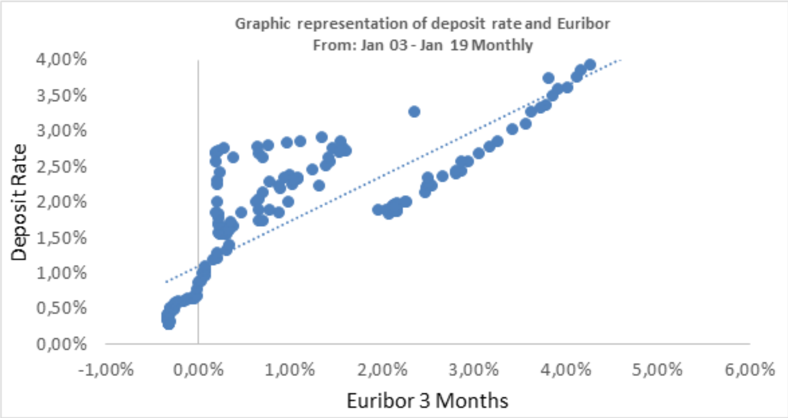

Figure (7): Deposit rate and market rate in Euro-Zone.
The scatter plot represents the deposit rate and market rate from January 03 – April 19.

The figure 7, for the European money market represents the linear relationship between the deposit rate and the Euribor 3M. In the case of the Euro zone, we observe that the deposit rate depends on the market rate on different ways. Looking at the figure for the Euribor, we distinguish two periods: the first period goes from January 2003 to January 2015 when the interest rate is positive and the second period goes from January 2015 to January 2019 when we observe the negative interest rate. In any case, the asset liability manager must cover the difference between the market rate and the deposit rate.

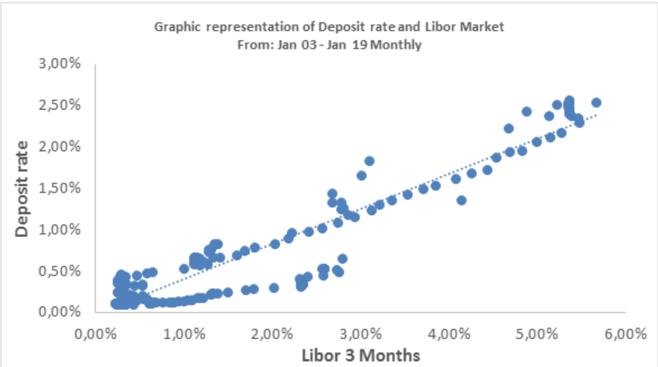

Figure (8): Deposit rate and market rate in US
The scatter plot represents the deposit rate and market rate from January 03 – April 19.

The second figure 8, for the US money market represents the relationship between the deposit rate and the Libor rate for the US zone. We observe that the deposit rate depends more regularly on the interest rate than for the Euro case. In figure 5, we observe two periods: the first period lies from January 2003 to January 2009; it corresponds to the period before crisis, where interest rates have high values with an average of (3.27%); the second period (i.e. from January 2009 to January 2019) corresponds to the period after the financial crisis where we observe low interest rates with an average of (0.76%). For example, when we perform a linear regression of the US M2 own rate [7] Upon the 3-month Libor rate, the residuals feature with M2 growth.

We get the estimation parameters by linear regression in the case of US and Euro namely:

$$g(L_t) = \alpha + \beta L_t$$

Table 5, provides the parameter estimations for this linear regression, namely 2003-2019.

Market	**Deposit Rate**	**Related Market Rate**	**α**	**β**	**ρ**
US	Deposit rate	3M Libor	-0.00022609 (0.00024)	0.42267 (0.0101)	0.95
Euro-Zone	Deposit rate	3M Euribor	0.011007 (0.0005)	0.63326 (0.010)	0.88

Table 5 provide the estimated[8] relationship between deposit rate and market rate in the US and in Euro Zone, the estimation period from Jan 03 – Jan 19 (monthly) data.

Looking at the parameters values, we note that deposit rates do vary significantly depending on the market rates. However, the very high value of parameters rho means that the deposit rates are highly correlated to market rates, as it can be expected. Looking at both demand deposits and market rate fluctuations, clearly we have to hedge the interest rate margins. As illustrated in what follows, it is possible to derive optimal hedging strategies in the case where the deposit rate is a linear function of the market rate.

Market 1997-2019	**Demand Deposit**	**Market Rate**	σ_L	σ_K	**ρ**
US	Deposit rate	3M Libor	0.51%	3.49%	-0.2208
Euro-Zone	Deposit rate	3M Euribor	2.28%	8.46%	0.0640

Table 6 provide the volatility of demand deposit and market rate in the US and Euro Zones and correlations for variables.

We notice that monetary deposits vary significantly from one aggregate to another and when switching from a marketplace to its submarkets. This may also occur among individual banking establishments and their subsidiaries, and when modifying the perimeter among monetary deposits. In the Euro zone, the volatility of monetary deposits is higher than in the US zone, with a lower correlation between interest rates and monetary deposits. In the Euro zone, we observe the high volatility of the amount of deposits (8.46%) seems to be largely due to changes in interest rates (2.28%).

[4]See Federal Reserve Bank of Saint Louis, https://fred.stlouisfed.org/series/M2OWN

[8]Table 5 contains the estimations of α and β corresponding to the linear regression of the deposit rate on the market rate $g(L_t) = \alpha + \beta L_t$. We find α = -0.022% and β = 42.26% for the US case, and in the case of Euro Zone we find α = 1.10% and β = 63.32%.

3 The Risk Management of Demand Deposits and Market rates

In this section, we aim at reducing the interest rate margin's variance, for some given maturity T. In what follows, we define a payoff corresponding to a hedging strategy of the interest rate margin for the quarter [T,T+ $\frac{1}{4}$]. Yet, most banking practices tend to design hedging strategies on interest rate securities to alleviate the volatility of the net interest income at historical cost. The asset liability manager must hedge both interest rate and demand deposit to ensure a positive interest rate margin. For this purpose, we introduce a quadratic hedging criterion allowing us to get an explicit hedging strategy that we further analyze. We note that, this kind of hedging strategy is based on mean-variance approach.

3.1Static quadratic hedging for interest rate margins

We assume that the demand deposit amount follows:

$$dK_t = K_t(\mu_K + \sigma_K dW_{K,t}),$$

where ($W_{K,t}$) is a standard Brownian motion. The trend μ_K and the volatility σ_K are assumed to be constant. Additionally, we assume that the forward market rate at date T for the time period of the interest rate margin -- a quarter -- follows a Market Rate Model , as defined in Brace *et al*. (1997).

$$dL_t = L_t(\mu_L + \sigma_L dW_{L,t}),$$

Where $L_t = L(t,T,T+\frac{1}{4})$ denotes the forward market rate and $W_{L,t}$ is a standard Brownian motion under some historical probability measure P. For model simplicity, μ_L and σ_L are assumed to be constant and we denote the related interest rate risk premium by $\lambda = \frac{\mu_L}{\sigma_L}$. We will thereafter be able to account for higher average returns when investing in long term bonds than in short-term assets. The framework can readily be extended with extra -- but reasonable -- computation when both μ_L and σ_L depend upon the forward market rate. In what follows, we consider the following optimization problem:

$$Min_{S\in H_1} Variance[S - IRM(K_T, L_T)]$$

Where (H_1) is the set of linear payoffs with respect to the market rate, namely:

$$H_1 = \{S|S = \theta(L_T - L_0)\},$$

where θ is a constant. Such hedging strategy is based on Forward Rate Agreements (FRAs) contracted at initial date. The problem deals with risk minimization with the interest rate margin as the only objective, such that there is no minimal return constraint on the final income.

Proposition The solution of problem is given by:

$$S^* = \theta^*(L_T - L_0) with \theta^* = \frac{Covariance[L_T ; K_T(-\alpha - (\beta - 1)L_T)]}{4Variance[L_T]}.$$

Proof. We have:

$$Variance[S - IRM(K_T, L_T)] =$$

$$Variance\left[\theta(L_T - L_0) - \frac{1}{4}K_T(L_T - \alpha - \beta L_T)\right] =$$

$$\theta^2 Variance[L_T] + \frac{1}{16}Variance[K_T(\alpha + (\beta - 1)L_T)] - \frac{\theta}{2}Covariance[L_T ; K_T(\alpha + (\beta - 1)L_T)].$$

The previous term is a polynomial function of order 2 with respect to θ . Its minimum is reached at:

$$\theta^* = \frac{Covariance[L_T\,; K_T\,(\alpha + (\beta - 1)L_T)]}{4Variance[L_T]}.$$

Corollary The expectation of the hedging cost is equal to:

$$\frac{Covariance[L_T\,; K_T\,(\alpha + (\beta - 1)L_T)]}{4Variance[L_T]}\left(L_0 - E_Q[L_T]\right) = 0.$$

The expectation and the standard deviation of the hedging error are respectively given by:

$$E_P[S^* - IRM(K_T, L_T)] =$$

$$\frac{Covariance[L_T\,; K_T\,(-\alpha - (\beta - 1)L_T)]}{4Variance[L_T]}(L_0 - L_0 e^{\mu_L T}) - E_P[IRM(K_T, L_T)],$$

with:

$$E_P[IRM(K_T, L_T)] = -1/4 \times$$
$$(\alpha K_0\, exp[\mu_K T] + (\beta - 1)L_0 K_0\, exp[(\mu_L + \mu_K + \sigma_L \sigma_K \rho)T]).$$

$$\sqrt{Variance[S^* - IRM(K_T, L_T)]} =$$

$$\frac{\sqrt{Variance[IRM(K_T, L_T)]Variance[L_T] - Covariance[L_T\,; I\,RM(K_T, L_T)]^2}}{\sqrt{Variance[L_T]}}.$$

Corollary Under assumptions of the processes $(L_t)_t$ and $(K_t)_t$, we get:

$$\theta^* = L_0 K_0 \times$$

$$\frac{\begin{pmatrix} \alpha\, exp[(\mu_L + \mu_K)T]\,[exp[\sigma_L \sigma_K \rho t] - 1] \\ +(\beta - 1)L_0\, exp[(2\mu_L + \mu_K + \sigma_L \sigma_K \rho)T]\,(exp[(\sigma_L^2 + \sigma_L \sigma_K \rho)T] - 1) \end{pmatrix}}{4L_0^2\, exp[2\mu_L T]\,(exp[\sigma_L^2 T] - 1)}.$$

We deduce in particular that, the optimal static hedging strategy θ^* has the following form with respect to the forward rate L :

$$\theta^* = \frac{A}{L_0} + B,$$

with:

$$A = K_0 \times \alpha \left(\frac{exp[(\mu_L + \mu_K)T]\,[exp[(\sigma_L \sigma_K \rho)T] - 1]}{4\, exp[2\mu_L T]\,(exp[\sigma_L^2 T] - 1)}\right),$$

$$B = -K_0 \times (\beta - 1)\left(\frac{exp[(2\mu_L + \mu_K + \sigma_L \sigma_K \rho)T]\,(exp[(\sigma_L^2 + \sigma_L \sigma_K \rho)T] - 1)}{4\, exp[2\mu_L T]\,(exp[\sigma_L^2 T] - 1)}\right).$$

Consequently, if the correlation ρ is negative, the optimal static quadratic hedging is decreasing with respect to the forward market rate if and only if the intercept α is positive. If the correlation ρ is positive, it is the converse.

3.2 Numerical illustrations

In what follows, we illustrate numerically the previous results. For this purpose, we consider the numerical base cases corresponding to our estimates for both Euro and US zones (for Euribor and Libor, we use estimations of μ_L and σ_L for the value of the intercept for the Euro zone, we take α=0.011 otherwise we get a negative expectation of the IRM.

- Euro zone case

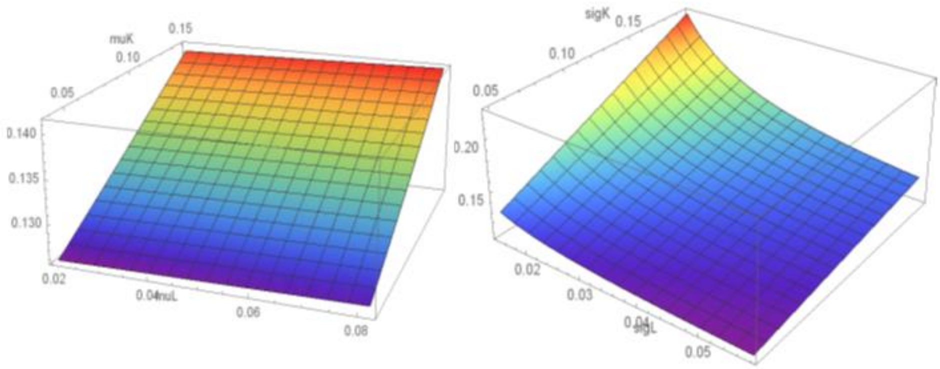

Figure 9: Hedging strategy as function of both the drifts (on the left) and both the volatilities (on the right) of the market rate and the demand deposits amounts in Euro zone.

Looking at the graph on the left, we can see that the optimal quadratic hedging strategy increases with respect to (w.r.t.) the trend of demand deposits and increases slightly w.r.t. the trend of the interest rate market. This is fairly intuitive: as demand deposits increase, the amount to be invested on the market rate increases. Looking at the graph on the right, we note that the optimal quadratic hedging strategy increases w.r.t. deposit volatility and decreases slightly w.r.t. market rate volatility.

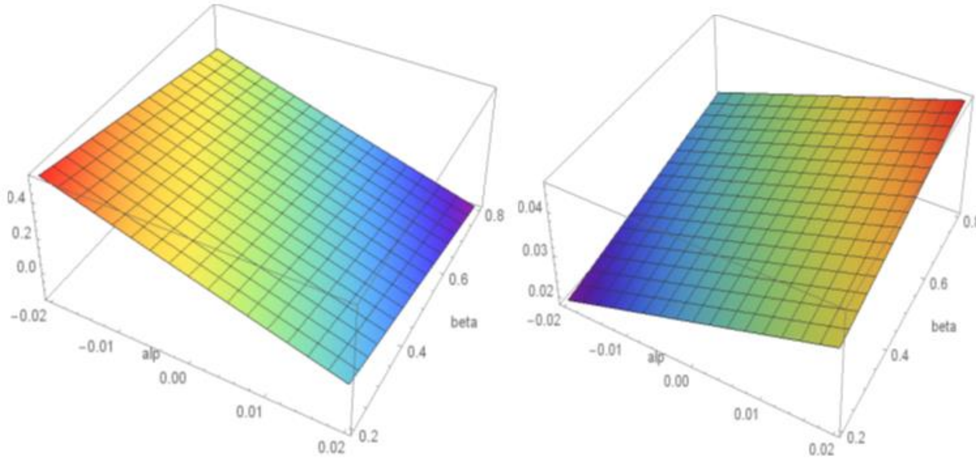

Figure 10: Static optimal hedging with respect to alpha and beta (on the left) and its percentage of hedging error (on the right) in Euro zone.

Looking at the graph on the left, we can see that the optimal static hedging strategy decreases w.r.t. intercept alpha, while it decreases slightly w.r.t. beta. This is due to the positivity of the correlation coefficient ρ (see Relations 13 and 14). The percentage of the hedge expectation increases w.r.t. intercept alpha and increasing slightly w.r.t. beta. This means that the percentage of hedging error increases w.r.t. the deposit rate.

- <u>US zone case</u>

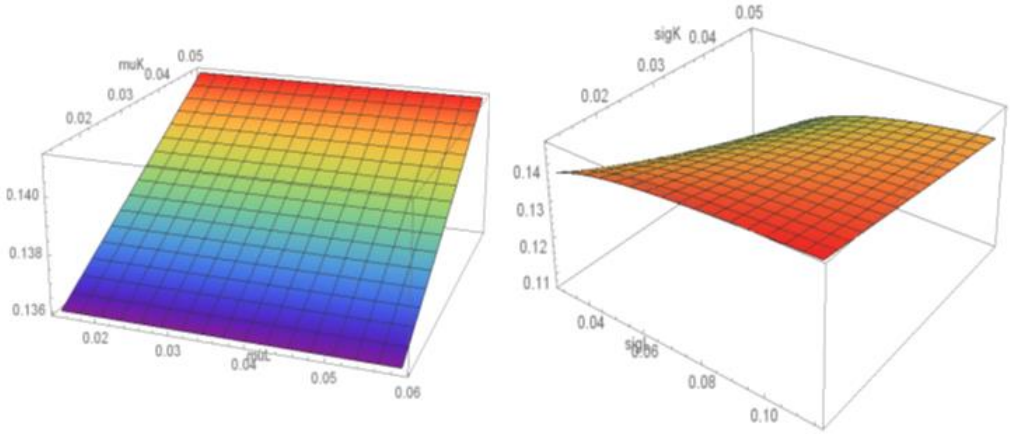

Figure 11: Static optimal hedging with respect to trends (on the left) and with respect to volatilities (on the right) in US zone.

Looking at the graphic on the left, we note that the optimal quadratic hedging strategy is increasing w.r.t. the demand deposit trend while slightly increasing w.r.t. the market rate trend. This is quite intuitive since the higher the demand deposit, the higher the hedging amount to be invested on the market rate. Looking at the graphic on the right, we observe that the optimal quadratic hedging strategy is decreasing w.r.t. the demand deposit volatility while increasing w.r.t. the market rate volatility.

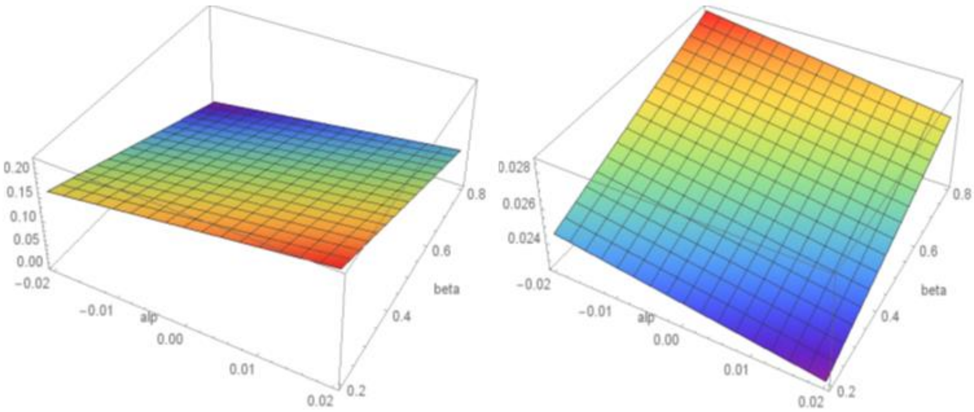

Figure 12: Static optimal hedging with respect to intercept and beta (on the left) and its percentage of hedging error (on the right) in US zone.

Looking at graphic on the left, we note that the static optimal hedging strategy is increasing w.r.t. intercept alpha while decreasing w.r.t. beta. The percentage of expectation of the hedging error is increasing w.r.t. intercept alpha while slightly increasing w.r.t. It means that the percentage of expectation of the hedging error is increasing w.r.t. the demand deposit rate. Compared to the Euro case, the sensitivity to intercept alpha is the converse. Indeed, for the Euro case the correlation rho is positive while for the US case it is negative.

Conclusion

Bank deposits management has become an important issue for banking institutions. In this paper, we deal with the mitigation of the risk contained in interest rate margins of demand deposits for the case of Euro and US zones. This paper computes the optimal strategy in order to hedge their interest rate risk. For this purpose, we have modelled the deposit rates as a linear function of the market rate, both in the case of the Euro Zone and the US during the period lying from January 2003 to April 2019. Assuming that the demand deposits carry some source of risk called business risk orthogonal to market risk, we have provided an explicit formula for the mean-variance hedging of the interest rate margins in the static case. Using a quadratic hedging strategy in a static framework instead of using options greek letters is not very expensive for the risk manager. We then provided numerical analysis of sensitivities of the hedging strategy, showing how the opposite signs of correlation and intercept of the two zones impact the hedge. Banks must set a remuneration that must be positive (rate + spread >0) while facing competition (see e.g. Banque de France, 2005). However, for the Euro zone, as a result of the cut in rates applied by the ECB, deposit-taking banks had to cope with a lower rate of remuneration on deposits, recently leading them to suppress the remuneration of accounts. One possible further extension would be to assume that deposit rate can be influenced by other macroeconomic aggregates (for example, inflation rate or the growth rate of GDP).

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