Probability of default using APT model: Case of Moroccan banking system

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18 August 2011

Abstract

In this paper we propose a measure of the probability of default of the Moroccan banking system through the model arbitration. We use a GMM estimation of financial data extracted from the Moroccan stock market over a period of 2000 to 2009 quarterly. The results obtained allow us to confirm that the default probability of major Moroccan banks (ATW, BMCE, BMCI and CDM) is low and its evolution remains moderate. In addition, results that were obtained after using the banking index confirms that the probability of Moroccan banking system is low since the volatility index remains acceptable.

JEL classification: G12, G21

Keywords: probability of default, Arbitrage pricing theory, financial stability, banking system.

Contents

1 Introduction

The work interested in banking sectors adapt themselves to the fact that there is a significant relationship between the business cycle and bank performance. Indeed, the financial stability of the banking system is linked to fluctuations in the macroeconomic framework, however, it proved by the experience of the international banking system soundness depends in addition to other endogenous factors and systems that are uncountable .

Financial stability is conditioned by a resilient banking system, which is the heart of the financial system. By allowing a reallocation of cash, it contributes to growth and economic development in different countries. However, and by its continuous exposure to the risk of transformation, it can be a source of fragility and instability of the financial and economic system.

Thus, the failure of a bank can result in an effective end to such transactions throughout the financial system, particularly within the system of payments and settlements. The size of this institution as important may be a key factor in the emergence of a systemic crisis leading to a subsequent bank runs and credit rationing. In this sense, the soundness of the banking system, may be called into doubt by the emergence of an idiosyncratic shock, such as the failure of a bank belonging to the system.

In this paper we propose to develop an indicator of the soundness of the banking system by calculating a probability of default of the Moroccan banking system. The first section presents a literature review of empirical studies on this issue. The second highlights the methodology used and the model adopted. The following section presents some stylized facts of the variables of interest. The final section presents the results and estimation and the probabilities of default obtained.

2 Literature review

Default probability greatly interested the authors to evaluate the soundness of the banking system, whose objective is to identify periods of high

stress. Quantifying the risk of failure allows authorities to monitor the health of the banking system and to implement measures to keep the banking system in place while avoiding episodes of systemic crises.

Mainly regulators seek to assess the risk associated with bank assets and liabilities and what the objective of determining the appropriate level of equity. Given the difficulty of determining the probability of failure of financial institutions on the basis of bank assets and liabilities, studies have focused on the values of financial institutions within the financial market.

According to financial theory, the value of shares reflect the real value of firms, since they can communicate the value of marching assets and liabilities. Indeed, the theory of efficient markets, considers that the fundamental value of the shares on the stock market reflects all information about the firms in question. Thus, the value determined by flow business Cash's possible to trace the value of firms at every moment in the stock market.

Work to measure the default probability of financial institutions have focused primarily on market data and on the foundations of option theory (Black and Scholes (1973) and Merton (1974)). However, the difficulty of applying for work on the options and the basics fairly hypothetical binding of other ways for the modern financial theory, were based on valuation models of asset prices to measure the probability of approaching and failing financial institutions.

Several studies have been based on the fundamental value of shares of banks to assess their probability of failure. Miles et al. (1988) used the CAPM to assess the probability of default of individual banks and this during a period between June 1975 and September 1987. So they come to confirm that there was a fairly large variation in the risk of bank failures throughout the analysis period. Clare (1995) using the arbitrage pricing theory (APT) has calculated the probability of default for insurance institutions and drawing on the approach of Miles et al. (1988). Bystrom (2004) studied a group of countries to determine the probability of default of different banking systems and finds that governance, laws and public order in the presence, negatively impact the probabil-

ity of failure of financial institutions, however it neglects the possible relationship between macroeconomic policy and the vulnerability of the banking system. Clare et al. (2002), with the Norwegian system data confirm an increase in the probability of default of domestic banks after the deregulation movement that has been undertaken during the 80s.

The approach we adopt in this paper is similar to that used by Clare et al. (2002). In fact we are referring to the market values of moroccan banks to assess the likelihood of failures. Using APT model we will try to identify the potential gap between the fundamental value of shares and securities and marching on the basis of this difference we will calculate the probability of failure of banks. Subsequently, we will try to establish an indicator for the entire banking system and on the basis of a banking index available on the moroccan stock market.

3 Methodology

Valuation models of asset prices can link the evolution of the expected return of financial assets to economic and financial factors. The CAPM Sharp (1962) links the financial retun to the development of an indicator of profitability and market it under the assumption that the financial market is efficient. As for the APT model he considers, in addition to the profitability of the market, other factors may affect the evolution of financial return. In this work, we rely on it and this by introducing the profitability of the market and other macroeconomic variables as explanatory factors.

According to financial theory, the price of an asset (V_t) is the ratio between the sum of prices of assets and liabilities (P_t) multiplied by the number of assets in market (X_t) and the number of shares (N) held by shareholders :

$$V_t = \frac{\sum_{t=1}^{T} P_t \times X_t}{N} \tag{1}$$

The stock market expected value of assets is approximated by the value of the previous period, since an efficient market the best prediction

and that of the previous period:

$$E(V_t) = V_{t-1} + E\left(r_f + \sum_{i=1}^{n} \beta_i \times F_i\right) \times V_{t-1} \tag{2}$$

Indeed, the expected value of the shares is equal to the realized value at time $(t-1)$ plus a fraction of the market generated by evolution, positive or negative, of factors affecting prices and based on APT model.

Using the value without the use of expected values we can write:

$$V_t = V_{t-1} + \left(r_f + \sum_{i=1}^{n} \beta_i \times F_i + e_t\right) \times V_{t-1} \tag{3}$$

With "e_i" is the error term generated by the APT model.

Generally, and the theory of efficiency, the difference between the value expected by equilibrium models should not be different from that achieved since the market price must necessarily reflected the fundamental value at all times and especially long run[1].

$$V_t - E(V_t) = e_t V_{t-1} \tag{4}$$

The greater the gap between the two values is more important to record the financial market during periods of stress or creation of financial bubbles indicating a deformation of the financial cycle and a slippage from the fundamental value. Based on this variation Miles et al. (1988) proposed a measure to assess the default probability of firms in the financial market. Indeed, one can measure the degree of deviation of the difference between two values by use of variance or standard deviation, in this case we can write:

$$V[V_t - E(V_t)] = V(e_t)V_{t-12} \tag{5}$$

In fact, the variance of the difference between the two values is equal to the volatility of the residual of APT model multiplied by the value of the previous time squared. This measure according to Miles et al.

[1] See the work E. Fama (1960) on the theory of efficiency

(1988) can be used to extract the default probability according to a simple proposition. The real value of assets varies, indeed, around the expectation approximated by the assessment model, this implies that one can measure the conditional variance of asset prices and at the same time that the value of financial firms . Thus the probability of default is the number of deviations from the mean (Santomero et al. (1977)).

$$\frac{V_{t-1}}{\sqrt{V\left[V_t - E\left(V_t\right)\right]}} = \frac{V_{t-1}}{\sqrt{V(e_t) \times (V_{t-1})^2}} = \frac{1}{\sqrt{V(e_t)}} \tag{6}$$

Substantial value of the ratio $1/\sqrt{V(e_i)}$ signifies a low probability of failure of a firm, while a low value is equivalent to a high probability. Empirical work, a ratio value equal to 2.326 is equivalent to 1% probability of failure.

4 Model adopted

According to the theory of arbitrage, return on assets is influenced by several economic and financial factors, such as profitability of the market and macroeconomic conditions. The model is as follows:

$$V_t = r_f + \sum_{i=1}^{n} \beta_i \times F_i + e_t \tag{7}$$

By moving to a presentation expectation we can write:

$$E(V_t) = E\left(r_f + \sum_{i=1}^{n} \beta_i \times F_i\right) \tag{8}$$

avec:

F_i : Are all factors that can influence the profitability of financial assets,

β_i : The parameters of the models and represent sensitivities to exogenous factors,

rf : the profitability of risk-free assets,

e_t : specific error.

The factors that we used and which are likely to influence the finan-

cial returns are: the profitability of the market and other macroeconomic factors, such as economic growth, the interest rate of treasury bills and development of general price level.

4.1 Introduction of inflation

Influences the price level in an effective manner the evolution of financial profitability. Indeed, the level of inflation significantly impact the cost of capital for firms whose composition is dominated by debts and obligations. A significant rate of inflation increases the nominal interest rate, which impacts rising prices of debt and interest rates imposed by the various donors.

However, inflation can directly impact the level of rate of return under a steady inflation (inflation targeting and / or price stability). Indeed, it is the irregular variations of this variable that can impact the price level in the stock market (signal extraction). In this regard, we chose to extract the irregular component of inflation that will be able to used as a factor in the evaluation model of asset prices and using the extraction function the irregular component in X12-ARIMA.

4.2 Economic growth

We chose like growth factor affecting asset prices and non-agricultural growth in the goal of eliminating agricultural component which is very volatile and that only marginally impact of industrial production. In the same way we extracted the irregular component for assigning rates of return on equity is decreasing or increasing and by using the X12-ARIMA.

4.3 The profitability of the market

In the light of financial theory, the return on assets is significantly correlated with the profitability of the market. In this regard, we opted for Moroccan market index "MASI" as an indicator of changing market conditions we extracted the rate of return.

4.4 The interest rate

In addition to the risk premium generated by changes in exogenous factors, investors must have a minimum share of profits due to their risk-taking. The choice of the riskless asset has accomplished the adoption of the interest rates of government bonds to 52 weeks.

5 Stylized facts and data presentation

The data we used were collected from the Casablanca stock exchange between 2000 and 2009 quarterly basis. The choice of frequency was carried out for a match between the business cycle and changes in stock prices.

We took all the banks which are listed on the Casablanca stock exchange ie, Attijari Wafa Bank, BMCE, BMCI and CDM. A data analysis was performed and in order to extract the statistical properties of different financial series. The table below presents some results:

Banks	**Average**	**Median**	**Max**	**Min**
ATW	0.01	0.01	0.48	-0.91
BMCE	0.03	0.03	0.73	-0.9
BMCI	0.02	0.008	0.58	-0.18
CDM	0.01	0.002	0.52	-0.16

Table 1: Descriptive statistics of financial returns

Average returns of the evolution of Moroccan banks are around 1 and 3% in quarterly frequency. Although the year 2008 has seen a sharp decline in the rate of return after the international financial crisis and recording levels down quite important at all commercial banks in the sample.

The macroeconomic series we have chosen to explain the evolution of financial returns and are included in the APT model showed a strong correlation with financial returns. The charts below show this correlation:

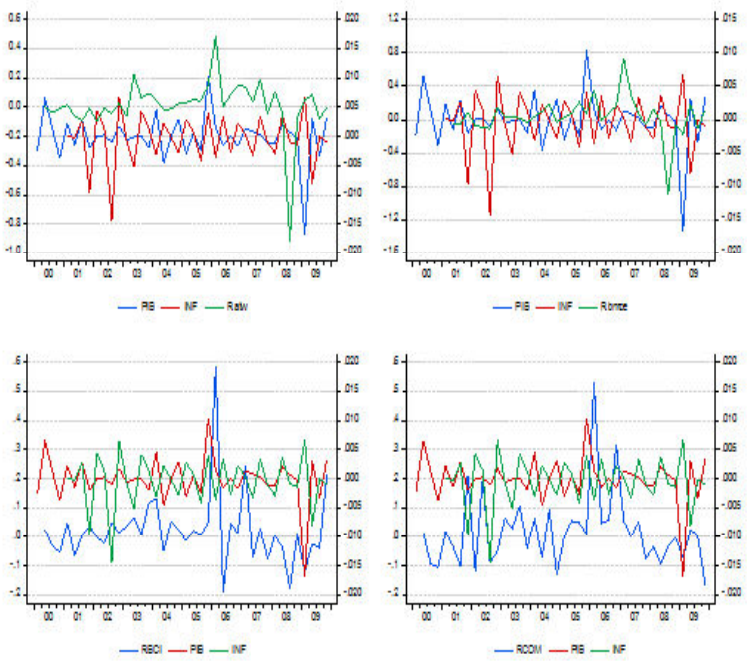

Figure 1: Evolution of financial returns and other factors

The series of inflation and GDP (PIB) are highly correlated with rates of returns of banks to strengthen the trade-off.

Moreover, the stationarity tests developed and used to verify that all series seem stationary, which validates the applicability of a linear regression on the various series. The table below summarizes the different results:

United root test	**Statistics**	**Probability**
ADF	18.29	0.00
PP	18.39	0.00

Table 2: United root test of financial returns

The critical probability is less than 5%, which validates the assumption of stationarity of the different series.

6 Model estimation and results

To estimate the model of arbitration we opted for the following presentation:

$$V_t = TB_t + \beta_1 Inf_t + \beta_2 pib_t + \beta_3 RM_t + e_t \quad (9)$$

With,

Rm_t: market profitability,

pib_t: irregular component of GDP,

Inf_t: irregular component of the inflation rate,

e_t: a residual of the model that follows a standard normal distribution.

When estimating the model, we chose a linear presentation while using an estimate by generalized method of moments (GMM) and to counteract the problem of weak exogeneity that may exist between the irregular components of inflation and growth. Otherwise, the choice of this method ensures a better quality of estimators which again became more robust and better describe the theoretical model.

The results obtained when estimating the various models with GMM are reproduced in the following table[2] :

Variables	**ATW**	**BMCE**	**BMCI**	**CDM**
Rm	0.853***	-6.125***	7.563***	-8.106***
PIB	6.637***	10.258***	-6.304***	4.300***
INF	11.921***	1.012***	0.501***	0.790***
R-carré	0.35	0.33	0.44	0.38
Test de Sargan	7.21 (0.95)	8.03 (0.96)	7.75 (0.93)	7.17 (0.95)

***:significant at 1%

Estimate with GMM method.

Corrections were made for heteroscedasticity using White's method.

Table 3: Résultats des estimations des modèles APT

[2] On test l'hypothèse nulle : E (Zi/ei) =0, avec Zi les variables instrumentales.

The results we obtained[3] to validate the relationship between macroeconomic factors and the profitability of bank assets. This implies that the arbitrage model can explain much of the evolution of stock returns. Shocks to the economic cycle are indeed important variables determining the exchange rate financial returns.

The instruments used have been corrected for simultaneity bias and confirmed the robustness of the coefficients. The Sargan test confirms these results with a critical probability greater than 0.05. Moreover, the Durbin-Wu-Hausman exogeneity could validate the instrumental variables used in estimating models.

In light of the results presented thus, we can extract the residue écartypes equations to obtain an assessment of the gap between the expectations of returns and real values. The inverse of écartypes represents an approximation of default probabilities of the various financial firms in our sample.

The following graphs represent the change in the probability of defects financial institutions:

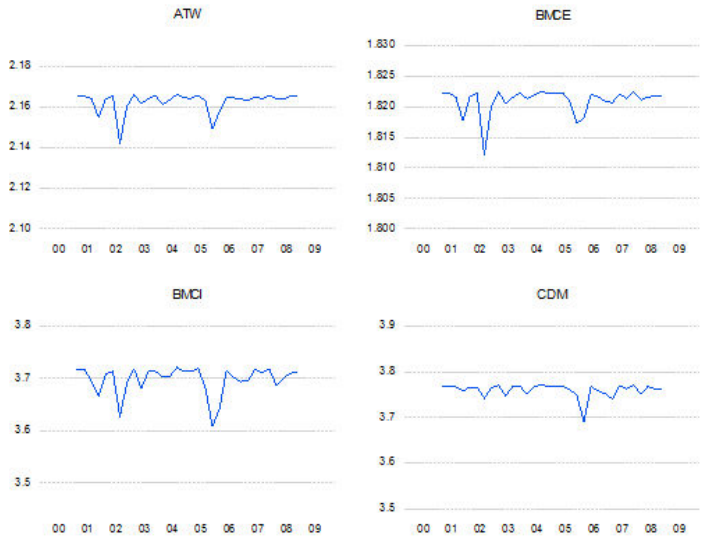

Figure 2: Evolution of probability of default

[3]The estimates were made by deducting returns the profitability of the riskless asset.

Default probabilities of the four banks remain stationary during the periods from 2000 to 2009, however, economic expansions recorded between 2005 and 2006 led to a decrease in the probability of default.

For the banking sector the probability of default can be represented in the same manner and by the use of écartypes model estimates (see Appendix for estimation results). Total probability of failure of the banking system is around 7% during the period of our study. However, the positive developments during 2005 and 2006 helped to bring this rate down to a level of 6.5%.

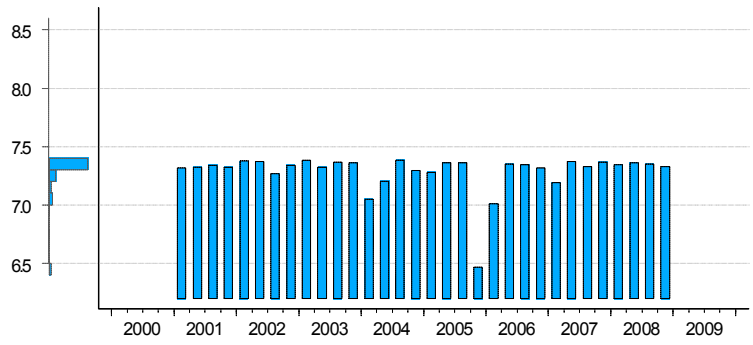

Figure 3: Probability of default of banking system in %

Note that in the evolution of the probability of default of the banking sector there is, in fact, three shocks that correspond to periods of strong economic growth and stabilization of inflation. These three periods have shown a strong trend in the total stock market.

However, the banking system, by level of default probability, remains stable and characterized by resilience, confirmed by a normal evolution of the value of all listed banks. Moreover, the results thus obtained can confirm that the market perception about the quality of banks is positive and that the players in the stock market consolidated their confidence in the performance of individual banks.

7 Conclusion

This work has allowed us to quantify the probability of default of the moroccan banking system through the stock prices of different banks traded the Casablanca stock exchange between 2000 and 2009 period.

The moroccan banking system, according to the calculated level of default probability, is stable and characterized by resilience, confirmed by a normal evolution of the value of all listed banks in the market. Moreover, the results thus obtained can confirm that the market perception about the quality of assets and investment banking is positive and that market players are consolidating their confidence in the performance of individual banks.

However, one can also argue that the effects of the global financial crisis have been significant changes in the probability of default of the banking system. Indeed, it was observed high volatility of returns bank from 2008, which resulted in an increase in the probability of default. However, the level of probability of default packets recorded by the Moroccan banking system remains low and indicates a strong resilience of the banking system with regard to the intrinsic value and basic banking stocks.

This indicator will be of great use for the various regulatory bodies, since its evolution may be an early indicator of banking turmoil. In addition, an assessment of the degree of bank default will, among others, to approach risk perception and quality of bank assets and plans, if necessary, strategies and policies to control and prevent and systemic banking crises.

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Appendix

Results of evaluation as GMM APT model of banking

Endogenous variable: bank stock index	
exogenous variables	**Coefficients**
RM	0.612 (0.00)***
PIB	1.505 (0.00)***
INF	-6.793 (0.00)***
R-carré	0.7
N°. instruments	15
Sargan test	7.21 (0.77)
Durbin-Wu-Hausman	0.673 (0.00)***

(***) : Significant at 1%