Financial Stability of the Turkish Banking Sector

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Abstract

In the narrow sense, financial stability is defined as price stability and the soundness of financial institutions. Although this definition can be extended to cover the functioning of financial markets, asset price volatility, risk management practices of institutions, etc., financial soundness of banks is still at the center of stability concerns. In this context, several methods have been developed to measure stability in terms of a common metric. In this paper, we analyze the stability of the Turkish banking sector in the period of 2000-2006 by applying an option theory based method that allows the estimation of default probability of the sector. We conclude that stability (default probability) was the weakest (highest) in 2001 and it entered in a healthy path after 2003. Furthermore, the sector resisted strongly to the May-June turmoil of 2006. Soundness of the sector remains relatively stable following the turmoil period.

Keywords: *Financial Stability, Option Model, Default Risk, Banking*
JEL Classification: *G12, G13, G33*

Özet - Türk Bankacılık Sektöründe Finansal İstikrar

Finansal istikrar, en dar şekliyle fiyat istikrarı ve finansal kuruluşların sağlamlığı olarak tanımlanmaktadır. Bu tanımın, finansal piyasaların işlevselliğini, varlık fiyatlarındaki dalgalanmayı, kuruluşların risk yönetim becerilerini ve benzeri hususları da kapsayacak şekilde genişletilmesi mümkün olmasına rağmen, bankaların sağlamlığı hâlâ istikrar kaygılarının merkezinde bulunmaktadır. Bu çerçevede, istikrarı ortak ölçütlerle belirlemeye çalışan yöntemler geliştirilmiştir. Bu çalışmada, temerrüt olasılığını tahmin etmeye yarayan ve opsiyon fiyatlamasına dayanan bir yöntemi uygulamak suretiyle 2000–2006 döneminde Türk bankacılık sektöründeki istikrarı analiz etmekteyiz. Bulgularımıza göre, istikrarın (temerrüt olasılığının) en zayıf (en yüksek) olduğu yıl 2001'dir ve istikrar 2003'ten sonra sağlıklı bir patikaya girmiştir. Ayrıca, sektör Mayıs-Haziran 2006 dalgalanmasına karşı güçlü bir şekilde dayanmıştır. Sektörün sağlamlığı, söz konusu dalgalanmayı takiben göreli olarak tekrar istikrarlı bir seyir izlemektedir.

Anahtar Kelimeler: *Finansal İstikrar, Opsiyon Modeli, Temerrüt Riski, Bankacılık*
JEL Sınıflaması: *G12, G13, G33*

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1. Introduction

Financial stability has been one of the most important issues for policy makers during the last decade both in developed and emerging economies. During this period, price stability and the soundness of financial institutions have been used commonly as a definition for financial stability. However, recent literature in this area suggests that financial stability is a more complex phenomenon which can not be described only with price stability and the soundness of financial institutions. Despite the fact that there is still no unique and widely accepted definition of financial stability, there are vital ingredients in various financial stability definitions. In this context, price stability (monetary stability), infrastructure of the financial markets, functioning of financial markets, soundness of financial institutions – usually understood as the banking stability-, confidence in financial institutions and relevant regulatory authorities, sound economic growth, asset price volatility, sustainable capital flows, reliable risk management practices of financial institutions, and the interaction between these variables are emphasized mostly together with the concept of financial stability. Among them, the stability of the banking sector is perhaps the most crucial element of financial stability.

While the definition of financial stability needs to be further explored, there is a growing interest in measuring financial stability in order to take proactive measures to avoid any sources of instability. Similar to the multi definition nature of financial stability, there are various ways of measuring it. The methods of measuring stability vary from a range of basic approaches to complex modeling techniques. Accounting and financial ratio analyses are used to examine the financial soundness of financial institutions. Statistical and econometric methods are more advanced approaches and have the advantage of doing in depth analysis or examination over a time period. Complex approaches like credit risk models (reduced form and structural approaches) are financial theory based and are employed to assess the financial stability of an individual institution, a sector or the financial system as a whole. Furthermore, credit risk models are better suited for implementing stress tests or analyzing the risk transfer mechanisms between different sectors of the economy.

In this paper, we apply Black-Scholes-Merton (BSM) model (Merton, 1974) which is within the class of credit risk models as classified above, also referred as KMV-Merton[1] model (Bharath and Shumway, 2004) for the period of 2000-2006 to estima-

(1) *KMV model is commercialized by Moody's and is referred as Moody's KMV model.*

te the probability of default (PD) for the Turkish banking sector. This study is a first attempt to use this model on the Turkish banking sector that covers the financial (banking) crisis period of 2000 and 2001. The rest of the paper is organized as follows.

In section 2, we try to summarize the literature in this field. Section 3 provides a brief overview of the Turkish banking sector with an emphasis on the financial crises observed in 2000 and 2001. The main properties of the BSM model applied in this study are summarized in section 4. In section 5, relevant data sources are explained and results of the estimation are provided. Section 6 concludes the paper with remarks on stability and policy issues.

2. Review of Literature on Measurement of Stability

The concept of stability is closely linked with the soundness of financial institutions and/or sectors. An institution can be considered as relatively stable if it has the capacity to fulfill its obligations or alternatively if it has a very low default probability in any circumstances. Contrary to this, it can be considered as instable if it can not meet its liabilities with the assets owned by the institution. Analogously, a sector can be seen instable if in aggregate, the firms in that sector will not be able to meet their obligations in a foreseen future. In reality, an institution may or may not default depending on internal factors, such as its financial stance and the external factors surrounding the institution. In a sense, statistically speaking, the occurrence of default can be seen as a random variable since there might be factors that are not controllable by the institution itself. That is why, financial stability measurement techniques rely on financial statements and/or probabilistic measures like probability of default. In this framework, measurement efforts on financial stability issues can be broadly distinguished in several ways.

A common distinction is made between micro and macro approaches (Van den End and Tabbae, 2005). For instance, financial soundness indicators of IMF are composed of a set of economic variables that are used as tools for assessing the strengths and the vulnerabilities of the financial system which requires the collection of micro and macro indicators. The IMF's system is useful in terms of providing a method that is easily applicable and allows for comparison on international levels. On the other hand, micro approaches can also be applied to specific institutions or portfolios to evaluate the stability concerns based on statistical figures.

Another differentiation can be made in terms of accounting based approaches and methods that require market data. To begin with, accounting based methods are the most known tools where financial ratios are used to compare different firms in the same sector or the performance of the same company in a given period of time. In certain sectors, financial ratio analyses are so common that it is used in periodical bulletins of relevant institutions or regulatory authorities. Financial ratio analyses have an intuitive insight since there are thresholds or rule of thumbs derived from historical experiences. For instance, in banking institutions, minimum capital adequacy ratios or liquidity requirements are set up by regulations in order to mitigate the risks of banks. Based on these critical ratios, one may make judgments on the financial stance of the relevant institution(s) or sector(s).

Besides, accounting data and financial ratios are sometimes merged with statistical and econometric methods to estimate the probability of default or determinants of default of individual firms or a sector. For example, ordered logit/probit estimations (Peresetsky et al, 2004), multivariate discriminant analysis and Z-Score models (Altman, 1968) are used widely in this area along with the accounting data based models.

In contrast with the accounting based analyses, structural models (also called macro-economic credit risk models) are dependent on market data. In these models, the liability and asset structure and their volatilities are used to predict the default probabilities of financial or non financial companies. The structural models stem from Black-Scholes' (1973) and Merton's (1974) seminal works on pricing of options. This method was further developed by KMV cooperation which was later acquired by Moody's. These types of models are applied to public companies (Tudela and Young, 2003, Vassalou and Xing, 2006), to banks (Chan-Lau et al, 2004) or to various sectors simultaneously (see, for example, Van den End and Tabbea, 2005). Other examples of such models are applied more comprehensively by taking the risk transfer mechanisms among the financial, real and public sectors (Gray et al, 2003). Option theory based contingent claims approach was also used to estimate the sovereign default risk of emerging market economies (Gapen et al, 2005).

Within the class of the macro-economic credit risk models, there are also approaches which are not of the nature of contingent claims analysis. For example, Van Lelyveld and Liedorp (2004) investigate the contagion risks in Dutch interbank market by means of interbank-lending matrix which is solved by a method called en-

tropy maximization[2]. Similarly, Virolainen (2004) employs a macro-economic credit risk model that requires the estimation of a singular econometric model to assess risk structure of the Finnish corporate sector and to conduct stress testing.

Unlike the international literature, studies in this field on Turkey are limited and macroeconomic theory based. These studies try to explain the sources of financial crises (instabilities) instead of measuring and quantifying it. For instance, Özatay (2004) summarizes the monetary and exchange rate policy of the central bank of Turkey in the post crisis period with a view to achieve price stability. On the other hand, Özatay and Sak (2003), argue that the 2001 crisis was triggered by a fragile banking system. According to this study, increase in currency and maturity mismatches coupled with the rise in nonperforming loans caused to a risk accumulation in the banking system. Interest rate and exchange rate risk were seen as the main sources of accumulated risk. Similarly, Uygur (2001) emphasizes not only the role of FX position of banks during the financial crisis but also other types of vulnerable macroeconomic fundamentals. However, none of these studies on Turkey use a financial theory based structural model to measure stability.

3. Overview of the Turkish Banking Sector

Turkish financial system is dominated by banking institutions. Currently, banks' assets constitute 88 percent of the total assets of the financial system. As of 2007 total assets of the banking sector is around 485 billion USD (Table 1). Major structural change in Turkish banking sector occurred after the introduction of financial liberalization policies in the 1980s. During this decade, ceilings on interest rates were abolished, interbank money market was set up, Capital Marked Board (CMB) and Istanbul Stock Exchange (ISE) were established to enhance the efficiency and competition in the financial markets.

Table 1: Main Indicators of the Turkish banking sector and National Income

Billion USD	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007
Loans	27	29	51	28	30	48	74	112	149	234
Deposit	33	44	102	81	84	111	143	181	211	295
Total Assets	58	67	155	116	130	179	229	296	346	485
GDP (1998 based series)	-	-	265	197	230	305	390	481	526	659

Source: Banks Association of Turkey (BAT), BRSA, Turkstat.

(2) *In this method, the aggregate exposure of lending and borrowing is divided proportionally over all banks in the sector and the distribution which maximizes the uncertainty, or entropy, about the outcome is calculated.*

Consequently, financial and non financial institutions started to implement initial public offerings on ISE to raise new funds. On the other hand, the government changed its borrowing policy from relying on external loans towards internal debt instruments. Thus, domestic borrowing instruments became increasingly important. While these reforms took place, de novo entry in the banking sector was eased, too. Hence, the number of deposit banks which was 52 in 1988 increased to 62 in 1999. High interest bearing and risk free government debt instruments motivated the de novo entries into the sector especially during the early 1990s.

At the same time, 1990s were the starting era of structural problems in the banking sector. In this period, banks began to decrease the amount of traditional banking activities in their portfolios and invested more in risk free government debt instruments. High borrowing requirement of the government accompanied by loose monetary policies culminated into a high inflationary environment that eventually led to prohibitively high real interest rates in the economy. Meanwhile, interest rate policies of the government created a "crowding out" effect for the private sector by demanding the bulk of the savings in the economy. Increasing risks in the financial system lowered the average maturity of savings and led to excessively high loan interest rates. In these circumstances, some banking groups with industrial and non industrial subsidiaries financed their own companies with the very short run and high interest rates. The Turkish economy and the financial system were further worsened by domestic political instabilities as well as by the international borrowing conditions for emerging markets during the late 1990s (crises in East Asia and Russia over the years 1997-1999). Moreover, inadequate level of own funds, maturity mismatch, high amount of non performing loans, high level of "open FX" positions (being short in FX), insufficient risk management practices, and bad governance contributed to the structural problems of the Turkish banking sector.

East Asian crises and the financial (FX) crises of 2000-2001 aggravated the weak financial stance of banks. As a result, a total of 21 banks were transferred to the Saving Deposits Insurance Fund (SDIF) between the years of 1997 and 2002 as they were not able to meet their liabilities. These banks were sold, merged or liquidated within the framework of the Banking Sector Restructuring Program. The implementation of this program amounted to a cost of one third of the domestic product as of 2002 under the full blanket guarantee system for deposits by the government (BRSA, 2003). Consequently, the number of deposit taking banks declined to 46 in

2001 and 40 in 2002 (see Table 2). It is interesting to note that among the banks transferred to the SDIF, only three of them were open to public on the stock exchange market (ISE).

Table 2: Number of banks in the Turkish banking sector

	1988	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total (*)	60	66	68	69	72	75	81	79	61	54	50	48	47	46	46
Deposit banks	52	56	55	56	59	60	62	61	46	40	36	35	33	33	33
Banks transferred to SDIF	-	-	-	-	1	1	6	3	8	1	1	-	-	-	-

Source: Banks Association of Turkey (BAT), BRSA.
(*) excluding participation banks.

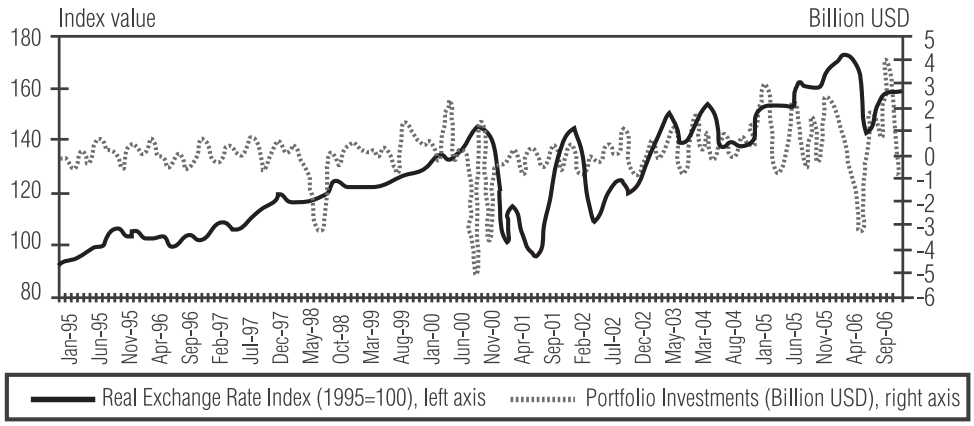
After the devastating financial crises of 2000-2001, the rehabilitation procedure with the aforementioned restructuring program of the banking sector produced very positive results. The strengthening of state, private banks and the improvement of the regulatory and supervisory framework contributed to the stability of the banking sector. As a matter of fact, by the end of 2006, the number of deposit banks decreased further to 33. However, this time the decline in the number of deposit banks was due to voluntary mergers and acquisitions as a result of the consolidation in the sector and the increasing competition concerns. Besides, both high economic growth rates following the recent crises and Turkey's accession towards European Union membership boosted foreign direct capital flows towards the banking sector which in turn increased considerably the franchise value of banks operating in Turkey.

Nonetheless, financial stability concerns continue to be an important feature of the sector when the behaviors of domestic and international investors are taken into account. For instance, in May-June 2006, similar to the other emerging markets, the high volatility in international capital markets created doubts about the sustainability of strength of the Turkish economy. Subsequently, the Turkish currency depreciated around 20% which was known to be overvalued against the hard currencies. As apparent from Figure 1, Turkish currency has been getting stronger in real terms against the basket of USD and Euro from the year 2002 till the May-June turbulence of 2006[3]. The dashed line in Figure 1 displays the volatile path of portfolio investments by foreign residents in Turkey[4].

(3) *The real exchange rate index (average of 1995=100) of central bank of Turkey is calculated by taking domestic and foreign price levels and is interpreted as follows; Turkish currency appreciates against USD and Euro when the value of the index rises and depreciates vice versa.*

(4) *Balance of payment statistics, central bank of Turkey. Positive values mean capital inflow, whereas negative values correspond to capital outflows.*

Figure 1: Reel Exchange Rate Index (1995=100)



The Turkish banking sector resisted strongly to the exchange rate shock despite its adverse effect on capital adequacy of the sector. During the May-June 2006 turmoil period the sector experienced loss in FX transactions which was compensated by interest income and gains in efficiency (BDDK 2006 and 2007[5]). Moreover, thanks to the regulatory limits on FX positions, open positions were not a major concern anymore and the sector recovered some portion of the losses and restored partially its capital adequacy ratio. From Table 3, it can be observed that after the turmoil in May-June 2006, profitability of the sector continued to increase, despite the losses in FX transactions, and the decline in capital adequacy of sector which fell from 23,5% (March 2006) to 18,6% in June 2006, increased again to 22,3% as of end 2006. It is clear from Table 3 that most of the on-balance sheet open position was hedged by off-balance sheet items eventually leading to a more sound banking system despite the presence of FX open position.

Table 3: Profitability, FX position and the capital adequacy of the sector

	September 2005	December 2005	March 2006	June 2006	September 2006	December 2006
Net profit (Billion NTL)	4,1	5,7	2,7	4,9	8,4	10,9
Net FX position (Billion NTL)	-0,4	-0,1	-0,9	-0,6	0,3	-0,4
-On Balance Sheet	-2,4	-2,5	-6,7	-9,2	-7,7	-2,4
-Off Balance Sheet	2,0	2,4	5,8	8,6	7,9	2,0
Capital adequacy ratio (%)	23,7	24,2	23,5	18,6	20,5	22,3

Source: BDDK (2006 and 2007).

(5) *This issue is explained in the profitability parts of these reports.*

Subsequently, many stakeholders of the financial system interpreted this period as a test of the banking sector and argued that important benefits were achieved via the strengthening efforts of the sector. But, as long as domestic currency remains to be overvalued and foreign capital inflows are volatile, stability concerns in the banking sector will be on the top of the agenda of the stakeholders.

4. Methodology

Black and Scholes (1973) and Merton (1974) have developed an option pricing model (contingency claims analysis) that can also be used to compute default measures for banks. According to this model, equity of a bank can be seen as a call option on the firm's (hereafter bank) assets. Basically, the liability side of the balance sheet of a bank is composed of debt and equity. The equity holders have the right but not the obligation to pay back the debt to the creditors of the bank and take the remaining of the assets of the bank. In other words, the holders of the equity can demand the residual assets after all liabilities are paid back to the debt holders. To put it differently, equity is a call option on the bank's assets with strike price equal to the book value of the bank's liabilities (Vassalou and Xing, 2006).

In this model, the market value (V_A) of a bank's underlying assets follows a geometric Brownian motion with an instantaneous drift (μ) and volatility (σ).

$$dV_A = \mu V_A dt + \sigma_A V_A dW \qquad (1)$$

In equation (1), W is a standard Wiener process. The book value of debt at time t is denoted by D which will mature at time T. The market value of bank's equity (V_E) is a call option on V_A and according to the model their relationship is defined by the following equation.

$$V_E = V_A N(d_1) - D\, e^{-rT} N(d_2) \qquad (2)$$

In equation (2), N(.) is the cumulative standard normal distribution, r is the risk free rate and the parameters d_1 and d_2 are related through the following equations.

$$d_1 = \frac{\ln(V_A / D) + (r + 0.5\sigma_A^2)\, T}{\sigma_A \sqrt{T}} \qquad (3)$$

$$d_2 = d_1 - \sigma_A \sqrt{T} \qquad (4)$$

Besides, it is shown that (Hull, 2000) the volatility of equity and assets are related via equation (5) that holds instantaneously.

$$V_E \sigma_E = \sigma_A \, N(d_1) \qquad (5)$$

Market value of equity can be derived from the market data on equity prices for banks whose shares are traded on the stock exchange market. Risk free rate r and maturity of debt (T) are also observable parameters. Market value of assets and its volatility have to be derived from the above equations by means of an iterative procedure.

As stated in Crosbie and Bohn (2003), default takes place when the market value of the bank's assets is less than the book value of debt (D) at the time of maturity. Alternatively, default happens when the ratio of market value of assets to book value of debt is less than one. Hence, the probability of default (PD) is the probability that market value falls below the book value debt at time T.

$$PD_t = Pr\left(V_{A,t+T} \leq D_t \mid V_{A,t=0}\right) = Pr\left(\ln V_{A,t+T} \leq \ln D_t \mid V_{A,t=0}\right) \qquad (6)$$

This equation is only an indication of default occurrence and should be interpreted cautiously. A bank may continue to service its debt due to long term nature of its liabilities. Nevertheless, the change of PD value over time can be used as an indication of the distress in the banking sector.

Using equation (1), asset value path (with μ and ε being the expected return and the random component of the assets, respectively) is given as follows;

$$\ln\left(V_{A,t+T}\right) = \ln\left(V_{A,t}\right) + \left(\mu - 0.5\sigma_A^2\right) T + \sigma_A \sqrt{T}\, \varepsilon_{t+T} \qquad (7)$$

where ε is distributed standard normal. Combining equation (6) and (7), probability of default is found as

$$PD_t = Pr\left(\ln\left(V_{A,t}\right) + \left(\mu - 0.5\sigma_A^2\right) T + (\sigma_A \sqrt{T}\, \varepsilon_{t+T}) - (\ln D_t) \leq 0\right) \qquad (8)$$

which can be rearranged as in equation (9).

$$PD_t = Pr\left(-\frac{\ln\left(\frac{V_{A,t}}{D_t}\right) + \left(\mu - 0.5\sigma_A^2\right) T}{\sigma_A \sqrt{T}} \geq \varepsilon_{t+T}\right) \qquad (9)$$

From the normality assumption about the term ε of the BSM model, equation (9) can be converted to

$$PD_t = N(-DD) = N\left(-\frac{\ln\left(\frac{V_{A,t}}{D_t}\right)+\left(\mu-0.5\sigma_A^2\right)T}{\sigma_A\sqrt{T}}\right) \quad (10)$$

where distance-to-default (DD)

$$DD = \frac{\ln\left(\frac{V_{A,t}}{D_t}\right)+\left(\mu-0.5\sigma_A^2\right)T}{\sigma_A\sqrt{T}} \quad (11)$$

shows how many standard deviations further from the mean are required for default to materialize.

Several properties of this approach need to be explained. Firstly, the model assumes that the information value inherent in the market prices and financial statements are not beatable. In other words, market values contain all the relevant information about factors that are the main determinants of default risk. Secondly, current values of the bank are used to estimate the future values of default risk. Thirdly and perhaps the most importantly, the model assumes that the random component (ε) of the assets follows a standard normal distribution. This assumption is considered to be a weakness of the BSM model. In fact, Moody's KMV model uses an empirical distribution which has fatter tail than the standard normal distribution to overcome this problem and provides more accurate probability of default values[6] (Crosbie and Bohn, 2003). Unfortunately, we do not have the chance to use an empirical distribution on default occurrences for Turkish firms.

For estimation purposes, we follow a procedure similar to the one that is used by Van den End and Tabbae (2005) in order to obtain the unobserved parameters of the model. First, observed volatility of equity (σ_E) is used as an initial estimate for σ_A and initial value of V_A is chosen arbitrarily. Next, by using equations (2) to (5), calculated σ_A and V_A values are used as inputs for the next iteration until the difference of successive calculations is less than 10^{-6}. Values satisfying this condition give us the estimated values of market asset value and asset volatility. As regards the prediction of drift term (μ) in equation (1), we use the mean log changes in implied asset values (V_A).

(6) *This issue is not the unique property of Moody's KMV-Model. It has a more complex estimation procedure than applied here and in other studies. Furthermore, the model allows for a detailed specification of the liabilities.*

However, in our calculations there are two main differences from the similar estimation procedures. First, because of the short term structure of liabilities[7], we run the model for a 3 months-horizon (T=1/4) whereas similar studies in this area usually assume a debt maturity of one year[8] (T=1). Second, to eliminate the effects of large data outliers, the median absolute deviation which produces more robust estimations is employed in calculating the implied volatility (σ_A).

5. Data and the Estimation Results

Our purpose in this study is to analyze the financial turmoil period and its aftermath using the model as explained in the previous section. For this reason, aggregate data of a number of publicly traded commercial (deposit taking) banks are used to predict the default probabilities which we interpret as the sector's stability indicator. The banks which are in our sample over the estimation period constitute at least 45 percent of the total assets of the sector. As of December 2006, 67 percent of the assets of the banking sector belongs to the publicly traded banks of which 70 percent is covered by the banks that we use for estimation purpose. By the end of 2006, 4 deposit banks are listed at the stock exchange after the financial crisis period so that these banks' data does not span over our estimation period. Therefore, remaining banks whose stock value data is available from beginning 1999 are included in our model. Obviously, this restricts the size of the sample. Nevertheless, used data covers those banks whose shares are mostly traded in the Istanbul Stock Exchange (ISE). When transaction volume is taken into account it is observed that by December 2006, 34 percent of the total transaction volume of ISE consisted of shares of commercial banks[9]. Listed banks in our sample correspond to 28 percent of the total transaction volume of ISE. In other words, 81% of the transaction volume of banks' shares is covered in our sample. As a result, the information value inherent in the share prices of these banks should not be underestimated. Thus, given our motivation for this study and under these data constraints, we believe that we have chosen a fairly good sample over the possible longest period.

Given the disadvantages of the model arising from the standard normal assumption of market values of assets and the lack of an empirical distribution for Turkish companies in this area, it is likely that probability of default values are overestima-

(7) *The arithmetic average of maturity of deposits is approximately 3 months (BRSA, 2004).*

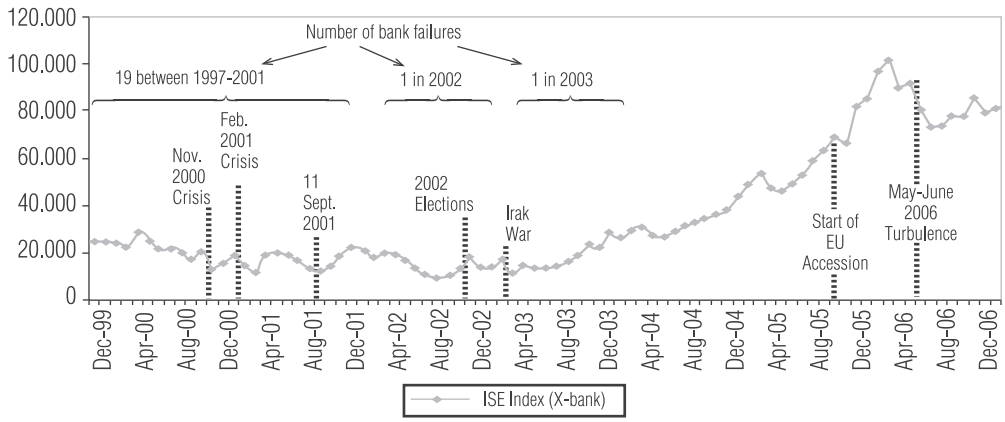
(8) *In fact we run the model also for one year. However, 3 months assumption is more realistic for Turkish banking sector. Moreover, estimations with 1 year horizon produces under or overestimated DD and PD that is difficult to justify.*

(9) *Deposit banks, participation banks and investment and development banks.*

ted or underestimated[10]. However, the method is still useful in the sense that if probability of default is constantly increasing, then we may interpret this event as an increment of the distress (instability) in the sector. To the contrary, we may conclude that there is an increase in the stability of the banking sector in the periods of declining probability. Thus, rather than paying much attention to the absolute value of the probability values, we are interested in its behavior (change) over time.

Share prices for publicly traded banks are available from the Istanbul Stock Exchange (ISE). Therefore, market value of equity is computable. The risk free interest rate (r) is the simple average borrowing rate on the Turkish Treasury for domestic debt instruments with maturity of 3 months (T=1/4). This data is regularly published by the Treasury of Turkey on a monthly basis. Market value of assets and volatility of assets are derived from the model as explained in section 4. Data on the book value of debt are available from the Banks Association of Turkey (BAT)[11]. Estimation period is 2000-2006 on a monthly basis where past 12 months working day's data of market value and volatility of equity have been used to infer the monthly predictions[12].

Figure 2: ISE Banking Sector Price Index



Before providing the estimated DD and PD values, it will be useful to understand the change in "market prices" of the banking sector. Figure 2 provides a plot of the ISE price index of publicly traded Turkish banks (X-bank index[13]). The index displayed an upward trend till the beginning of 2000 and thereafter became relatively mo-

(10) *Equation (5) will tend to overestimate asset volatility and accordingly PD, if the market leverage is decreasing quickly. Conversely, if leverage is inclining rapidly then asset volatility and PD will be underestimated as stated by Crosbie and Bohn (2003).*

(11) *Book value of debt is derived from quarterly balance sheet data of BAT. Quarterly data is interpolated to obtain monthly figures through the spline function of the R software.*

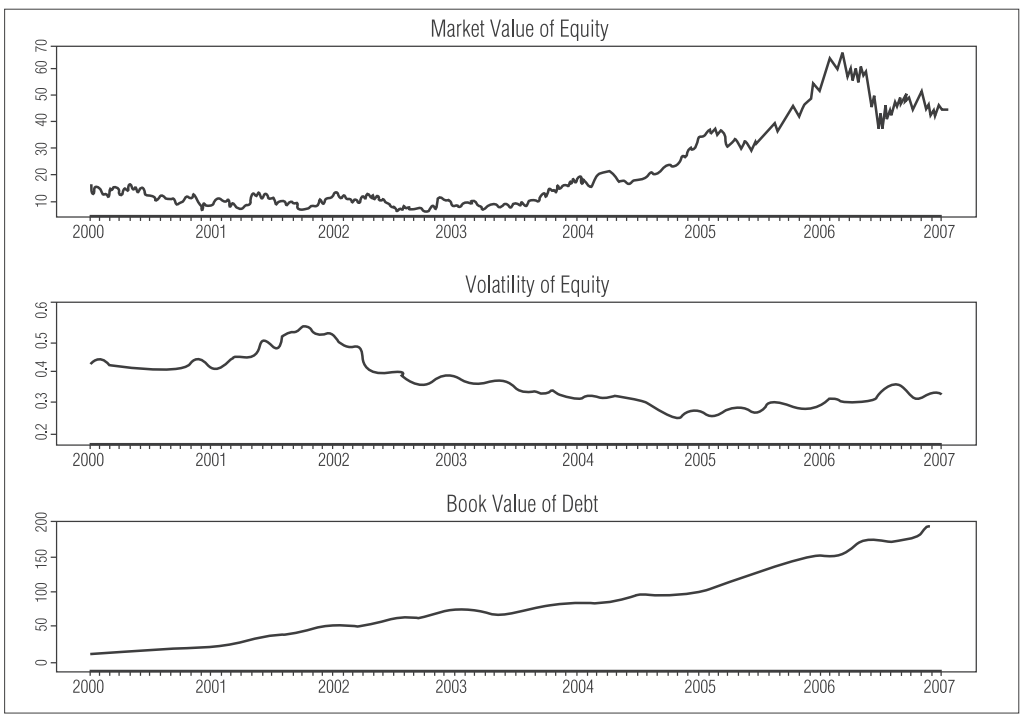
(12) *In other words to estimate the year 2000 data on 1999 is needed.*

(13) *Available from Reuters database.*

re volatile with a declining trend. In November 2000 it made a deep when the first distress of currency crisis was observed. Another low level was attained in February 2001 when the huge currency crisis occurred that forced the government (central bank) to shift to a free floating exchange rate regime from the pegged one. The effects of September the 11th (2001) and the general elections in November 2002 are clearly reflected in the X-bank index. Meanwhile, 19 bank failures were observed between the period of 1997-2001, and 1 in 2002 and 2003, respectively. Accordingly, the ISE bank price index which was above 24,660 points in 1999 went down to 13,815 at the end of 2002. The index displayed an upwarding trend after late 2003 until the May-June turbulence of 2006. Obviously, all the above mentioned developments had an effect on the share prices of publicly traded banks and therefore on the market values of them.

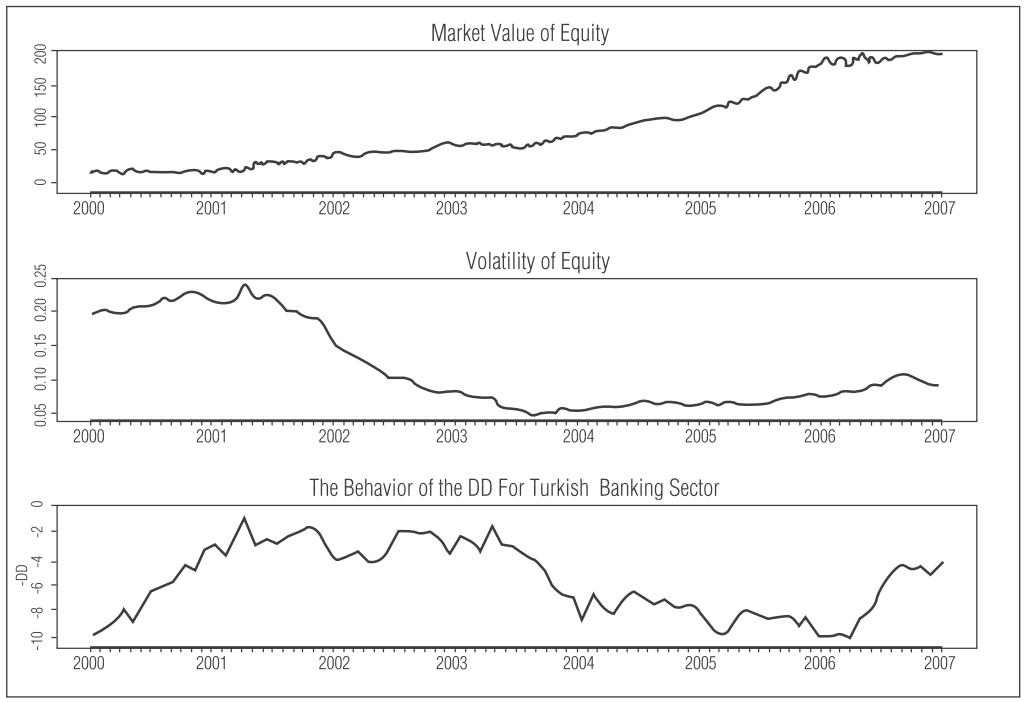
Figure 3 provides plots of the market value of equity (V_E), volatility of equity (σ_E) and the book value of debt (D) over the estimation period. Predicted values of market value of assets (implied V_A), volatility of assets (σ_A) and the distance-to-default indicator (DD) of the sector are plotted in Figure 4. For ease of exhibition, the negative distance-to-default indicator (-DD) is presented[14].

Figure 3: Market value of equity, volatility of equity and book value of debt



(14) *The increase in the "negative distance to default" means that smaller numbers of standard deviations are required for default to occur.*

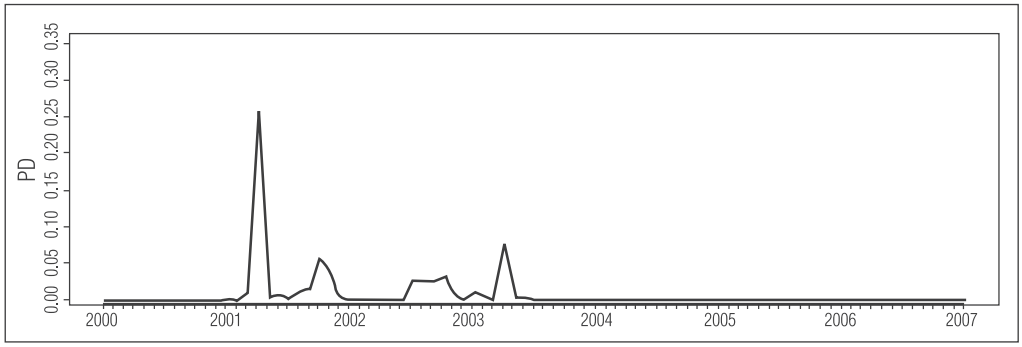
Figure 4: Market value of assets, volatility of assets and negative DD



As expected -DD increases with default risk. In our predictions, -DD increases after the year 2000 and attains its peak level in 2001 during the financial crisis. In the aftermath of the 2001 crisis, -DD is relatively high but volatile till the beginning of 2003. Later, -DD decreases starting from mid 2003 to the beginning of 2005 and inclines during the financial turbulence period of May-June 2006. Following this period -DD remains flat till the end of 2006.

The mapping of DD value to corresponding probability of default values via the standard normal distribution captures the financial distress period of 2001 and the fluctuating period of 2000-2003 (Figure 5). However, due to the tail properties of standard normal distribution, May-June 2006 turbulence is not reflected in PD indicator contrary to -DD. We think that the normal distribution underestimates the extreme tail events. An empirical distribution with leptokurtic property could capture the tail events more accurately and provide better estimates of PD.

Figure 5: Financial stability estimates (PD)



Nevertheless, as mentioned before we use DD and PD predictions as stability indicators of the sector. Thus, according to the results of the model, Turkish banking sector was extremely instable in 2001 and signs of instability were dominant till 2003. The sector has entered into a relatively stable path after the beginning of 2003 which seems to continue. Note that the May-June 2006 turbulence in the sector is captured by DD measure more sensitively than PD indicator.

6. Conclusion

In this paper, we apply an option theory based model to measure the financial stability in the Turkish banking sector between the years of 2000 and 2006. In contrast to the other studies on Turkey, this study attempts to provide a metric about financial stability of the Turkish banking sector that covers the financial crisis period of 2000-2001. The employed model shows that distance to default (DD) and related probability of default values of the sector varies over time. According to our findings, distance to default was smallest in 2001 when actually a number of banks failed and exited the system. However, according to our estimations the situation has improved after 2003. Following this year, even in May-June Turmoil of 2006, the DD values imply that larger numbers of standard deviations are required for default to occur compared to period 2000-2002.

Thus, we argue that stability of the Turkish banking sector has been increasing since 2003. Based upon these figures we believe that the sector is in a stronger position to resist shocks when compared to early 2000s. In fact, May-June financial turmoil period has been surpassed without any serious consequences with the help of regulatory and supervisory improvements in the sector and the overall economy.

However, overvalued domestic currency, volatile capital inflows, huge current account deficit, credit boom and other potentially destabilizing factors may affect the stability of the sector in the future. We believe that the model which was applied in this study might be used as a surveillance mechanism to assess the strengths and vulnerabilities of the sector. The approach used in this paper is not the unique way of measuring stability. Nevertheless, the employment of this approach with complementary methods will enhance the risk perceptions of the investors and the policy makers to adopt new strategies or regulations.

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