

EMPIRICAL STUDY OF THE PROBABILITY OF DEFAULT IN CASE OF ROMANIAN COMPANIES LISTED ON STOCK EXCHANGE

Petru Tünde Petra

Babeş-Bolyai University, Faculty of Economics and Business Administration

Farkas Dalma-Zsuzsa

Babeş-Bolyai University, Faculty of Economics and Business Administration

Furdek Balázs-Márton

Babeş-Bolyai University, Faculty of Economics and Business Administration

Marton Noémi

Babeş-Bolyai University, Faculty of Economics and Business Administration

Rácz Timea Erzsébet

Babeş-Bolyai University, Faculty of Economics and Business Administration

The importance of estimation of a firm's probability of default increased significantly during the economic and financial crisis for financial institutions, which can be explained by the fact that the share of nonperforming loans increased in this period. The probability of default can be estimated with structural models, which have on base the methodology developed by Merton (1974), methodology used by Moody's Corporation (known as KMV Merton model).

The aim of this study is to estimate the probability of default of companies listed on Bucharest Stock Exchange using this methodology.

This approach was widely used in the literature by many researchers (i.e., Kealhofer and Kurbat (2000), Crosbie and Bohn (2002), Duffie and Wang (2004), Bharath and Shumway (2004, 2008)). In Romania this methodology was empirically tested by Codirlaşu (2007), who estimated using Merton's methodology the probability of default of companies listed on the Bucharest Stock Exchange, respectively by Bobircă et al. (2008), where the probabilities of default were estimated in case of 42 companies listed on the Bucharest Stock Exchange for 2000-2008 time period.

In this paper we used Merton's model, which assumes that a company defaults if the value of its assets is less than the promised debt repayment at time T. The process of estimating the probability of default starts from the following firm specific variables: the market value of the firm's assets, the share prices, the value of the liabilities and the risk-free rate. The analyzed period is 2003-2010, containing the economic and financial crisis period, too. Analyzing the financial statements of the companies listed on the Bucharest Stock Exchange, we determined the input parameters of the model and calculated the quarterly probabilities of default of each analyzed company. According to our results the probabilities of default have a reduced value in the majority of the cases.

Keywords: Merton model, probability of default, credit risk, structural models, companies listed on the stock exchange.

JEL codes: G12, G17, G32, G33

I. Introduction

The importance of estimation of a firm's probability of default increased significantly during the economic and financial crisis for financial institutions, which can be explained by the fact that the share of nonperforming loans increased in this period. Nowadays, the question for the credit institutions and investors is not about to use statistic forecasting methods to estimate the default risk or not, it's rather about which method should be chosen. The purpose of this paper is to

estimate the probability of default in case of companies listed on the Bucharest Stock Exchange by using the Merton model, which is often used in the literature. This method can determine the probability that in subsequent period company will go bankrupt or not, based on the financial statements of each company. The Merton model prices the companies' assets and liabilities according to the theory of options. According to this model, a company goes bankrupt when the value of its liabilities exceeds the market value of its assets. The indicators used in the model are the market value of the assets, the share prices, the value of the liabilities and the risk-free rate. The investigated period is 2003-2010.

II. Literature review

The methodology developed by Merton was widely used in the literature by many researchers (for example Kealhofer and Kurbat (2000), Crosbie and Bohn (2002), Duffie and Wang (2004), Bharath and Shumway (2004, 2008)).

Duffie and Wang (2004) showed that the KMV Merton model can be used for the estimation of probability of default having a good predictive power. Tudela and Young (2003) investigated the probability of default (PD) of the companies from United Kingdom by using the Merton model. After the estimation of the probabilities of default the companies were divided into groups of defaulting and non-defaulting companies. An estimation of probability of default for the group of non-default companies was also made, with the purpose of controlling. To evaluate the results of the estimation made by the Merton model in relation with the companies' accounting information Probit-regression was used.

Erken (2008) studied that the Merton model is valid for the Dutch companies. He examined the KPN Company, which is the biggest Dutch company. The year 2000 was very instable for the firm, this way the examined period is from January 1st 2000 till December 31st 2000. The purpose is to show how this unfortunate year is reflected in the Merton model. The variables as financial information used in the model are the value of the firm namely the market value of the assets, the liabilities from the balance sheet, the risk free rate. Three steps were necessary to determine the probability of default: the estimation of the value of assets and volatility of assets, which was made by the Black-Scholes model, the calculation of the distance to default and the estimation of the probability default. Based on the case study and empirical research of KPN, as the result of the paper was established that the Merton model is appropriate for the estimation of the KPN company's probability of default, because in the examined unfortunate period the PD was 28.7%, while the volatility of assets 49.83%.

In Romania the model was tested empirically by Codirlasu (2007), who examined the probability of default (PD) for companies listed on the Bucharest Stock Exchange using the Merton model and its extension. The author analyzes 7 listed companies, and 5 investment funds between 1998 and 2006. As a conclusion he established that investment funds have the lowest (near zero) probability of default because of their diversified portfolios. From the companies, the SNP Petrom had the lowest PD, while the Oltchim had the highest PD between 2001 and 2004.

Bobircă et al. (2008) examined the probability of default for 42 companies listed on the stock market in the period of 2000 to 2008 by using Merton model. The results of their analysis show that nearly 20% of examined companies have probability of bankruptcy close to zero during the examined period, while the another 20% of companies have default probability of 50%. Between the two extreme values there were only a few companies.

III. Methodology

Merton in 1974 developed a model which prices the credits and liabilities of a company according to the theory of options.

Taking a company which finances the bought of (risky) assets (V) from two sources: the equity (E) granted by the shareholders and issuing a zero coupon bond (the nominal value of it is F , the maturity T and the market value B). The company is exposed to credit risk because of the loan, which means that in the moment T the value of the assets (V_T) is less than the nominal value of the liabilities (F).

The credit risk is present till the probability of default of the company is greater than zero (i.e., $P(V_T < F)$). In conclusion, at moment t_0 , we have that $B_0 < F \cdot e^{-rT}$, namely the yield of bond (y_T) is bigger than the risk free rate (r), furthermore the spread (π), a compensation for the assumption if the risk of the owners of the bond, can be stated as:

$$\pi = y_T - r.$$

If in the market there are no frictions, transaction expenses or expenses that appear if the company defaults, then the market value of the company's asset is equal with the sum of the equity and the value of the loan, that is:

$$V_0 = E_0 + B_0.$$

As a conclusion, the credit risk is the function of the company's financial structure:

- the leverage ratio, $LR = \frac{F \cdot e^{-rT}}{V_0}$;

- the volatility of the asset yield, σ_V ;

- the maturity of liabilities, T .

The basic idea of Merton (1974) is that if at moment T we have that $V_T < F$, then the company defaults and the value of its equity is 0. While if at moment T we have that $V_T > F$, then the firm is able to pay its liabilities and its capital values ($V_T - F$). Thus, at moment T the value of this company's capital is:

$$E_T = \max(V_T - F, 0).$$

Consequently, the value of a company's capital (E_t) can be seen as a call option on the market value of the firm's assets (V_t) and the trading price (F). So, E_t can be written as the following function $E_t = f(V_t, F, \sigma_V, r, T - t)$.

Using Black-Scholes's (1973) option pricing formula we get:

$$E_0 = V_0 \cdot N(d_1) - F \cdot e^{-rT} \cdot N(d_2),$$

where

$$d_1 = \frac{\ln \frac{V_0}{F} + \left(r + \frac{\sigma_V^2}{2} \right) \cdot T}{\sigma_V \cdot \sqrt{T}},$$

$$d_2 = d_1 - \sigma_V \cdot T.$$

The market value of the loan is $V_0 - E_0$.

The probability that a company goes bankrupt is $N(-d_2)$, and for the calculation of this, it is necessary to calculate the V_0 and σ_0 , but they are not directly observed. For companies that are listed on the stock exchange the value of the equity (E_0) can be estimated. Using Ito's lemma the equity volatility can be calculated:

$$\sigma_E \cdot E_0 = N(d_1) \cdot \sigma_V \cdot V_0.$$

Building a two-equation system on these relationships, we can estimate the values of V_0 and σ_0 .

IV. Main results

Our research includes 21 companies listed on the Bucharest Stock Exchange. We selected those companies, which have fulfilled our predefined criteria for liquidity. Under the liquidity criterion a company was analyzed, if the company's the annual number of transactions exceeded the 0.5% threshold for the total annual transactions of listed companies. The following companies were included in our sample:

- Financial intermediaries: SIF1, SIF2, SIF3, SIF4, SIF5, BRK.
- Extractive industry: SNP, DAFR, PTR.
- Processing industry: AMO, AZO, OLT, ATB, BIO, ALR, EPT, CMP, - TBM, RRC.
- Heat and electric energy: TEL.
- Transport and storage: OIL.

We collected the data of these companies for the period of 2003. IV. – 2010. III. The input data are the followings:

- accounting value of the assets of the company;
- accounting value of the company's short / long-term obligations;
- market value of the company's capital, which is calculated as the product of the value of issued shares by the company and the market price of shares;
- volatility of the annual stock price (as a proxy variable for the market value of equity), which is based on the calculation of the $\sigma \cdot \sqrt{t}$ formula, where the daily volatility is σ and the number of days(250) is t ;
- average of the monetary market rate as a proxy variable for risk-free rate.

In order to determine the probability of default, it is necessary for a hypothesis regarding the volatility of the assets of the company. We assumed that this value ranks between 20% and 40%. The model was estimated using the Matlab program.

Appendix 1 summarizes the results of Merton model, the probabilities of default of the 6 companies operating as financial intermediaries. It can be seen that the values are very low, almost 0 %. Higher values may be noticed only in the case of the BRK Company in the first three quarters of 2005, but it can be seen that the following periods have more reduced probabilities of the default.

In *Appendix 2* we summarized the results of the Merton model estimation of 5 companies, which carry out their activities in the following 3 areas of activity: extractive industry, heat and electric energy, transport and storage. It can be seen that the values in many cases remains low, which means that it is almost 0% the probability that any of the companies defaults next year. We can observe a few higher values of estimated probabilities, which mean that the probability for a company to become insolvent in the subsequent period is higher.

The *Appendix 3* contains the results of the Merton model regarding the probabilities of default of some of the companies operating in manufacturing sector. We can observe that the values can vary from a minimum value of 0.00% to a maximum value 95.87%. The high values can also indicate that the share price of the company dropped considerably in the examined period.

V. Conclusions

In this article we analyzed the probability of default of 21 companies listed on the Bucharest Stock Exchange, using the Merton methodology in 2003-2010 time periods. The results show that this methodology can be used for the estimation of probability of default in case of Romanian listed companies. Our results are in accordance with the earlier studies. The estimated probabilities of default are higher in the economic and financial crisis period. As further research can be concern the comparison of the prediction power of the structural models with other

models used for the estimation of the probability of default (such as: discriminant analyses, logit regression, neural networks) in case of Romanian companies.

VI. References

1. Bharath, T. Sreedhar and Shumway, Tyler. "Forecasting Default with the Merton Distance to Default Model". *Review of Financial Studies* 21(2008):1339-1369.
2. Bharath, T. Sreedhar and Shumway, Tyler. "Forecasting Default with the KMV-Merton Model". *Social Science Research Network* (2004):1-36.
3. Black, Fischer and Scholes, Myron. "The Pricing of Options and Corporate Liabilities". *Journal of Political Economy* 7(1973): 637-654.
4. Bobircă, Ana, Lupu, Radu, Miclăuș, Paul-Gabriel and Ungureanu, Ștefan. "Expected default frequencies for the companies listed at the Bucharest Stock Exchange". *Analele Universității din Oradea. Științe economice* (2008):337-342.,
5. Codirlasu, Adrian. "Managementul Riscului Financiar-Valutar". *Teză de doctorat, Academia de Studii Economice, București* (2007): 65-71.
6. Crosbie, Peter J. and Bohn, Jeffrey, R. "Modeling Default Risk," Research Paper, Moody's KMV (2002).
7. Duffie, Darrell and Wang, Ke. "Multi-Period Corporate Failure Prediction with Stochastic Covariates," Working Paper (2004), Stanford University.
8. Erken, L. J. "Case Study: KPN, The Merton model for default probabilities: a valid model for Dutch Companies?". *Bachelor thesis Finance* (2008): 1-22.
9. Kealhofer, Stephen and Kurbat, Matthew. "Benchmarking Quantitative Default Risk Models: A Validation Methodology, Research Paper (2000), Moody's KMV.
10. Merton, Robert C. "On the pricing of corporate debt: The risk structure of interest rates", *Journal of Finance*, 29(1974): 449-470.
11. Tudela, Merxe and Young, Garry. "A Merton-model approach to assessing the default risk of UK public companies", *Science Research Network, Bank of England Working Paper 194* (2003): 1-38.
12. ***Bursa de Valori București, Accessed January 23, 2011. www.bvb.ro
13. ***Banca Națională Română, Accessed March 12, 2011. www.bnr.ro
14. ***Sif Banat-Crișana, Accessed February 18, 2011. www.sif1.ro
15. ***Sif Moldova, Accessed February 18, 2011. www.sif1.ro
16. ***Sif Transilvania, Accessed February 18, 2011. www.siftransilvania.ro
17. ***Sif Muntenia, Accessed February 18, 2011. www.sifmuntenia.ro
18. ***Sif Oltenia, Accessed February 18, 2011. www.sifolt.ro

VII. Appendices

Appendix 1: Annual probability of default in case of companies with the following stock symbols SIF1, SIF2, SIF3, SIF4, SIF5

	SIF1	SIF2	SIF3	SIF4	SIF5
2003 Q1	0,00%	0,00%	5,31%	0,00%	4,23%
2003 Q2	0,00%	0,00%	3,27%	0,00%	3,76%
2003 Q3	0,00%	0,00%	4,53%	0,00%	4,06%
2003 Q4	0,00%	0,00%	3,27%	0,00%	3,15%
2004 Q1	0,00%	0,00%	2,38%	0,00%	0,00%
2004 Q2	0,00%	0,00%	0,00%	0,00%	0,00%
2004 Q3	0,00%	0,00%	1,07%	0,00%	0,00%
2004 Q4	0,00%	0,00%	0,00%	0,00%	0,00%
2005 Q1	0,00%	0,00%	0,00%	0,00%	0,00%
2005 Q2	0,00%	0,00%	0,00%	0,00%	0,00%
2005 Q3	0,00%	0,00%	0,00%	0,00%	0,00%
2005 Q4	0,00%	0,00%	0,00%	0,00%	0,00%
2006 Q1	0,00%	0,00%	0,00%	0,00%	0,00%
2006 Q2	0,00%	0,00%	0,00%	0,00%	8,28%
2006 Q3	0,00%	0,00%	0,00%	0,00%	0,00%
2006 Q4	0,00%	0,00%	0,00%	0,00%	0,00%
2007 Q1	0,00%	0,00%	0,00%	0,00%	0,00%
2007 Q2	0,00%	0,00%	0,00%	0,00%	0,08%
2007 Q3	0,00%	0,00%	0,00%	0,00%	0,00%
2007 Q4	0,00%	0,00%	0,00%	0,00%	0,00%
2008 Q1	0,00%	0,00%	0,00%	0,00%	0,00%
2008 Q2	0,00%	0,00%	0,00%	0,00%	0,00%
2008 Q3	0,00%	0,00%	0,00%	0,00%	0,00%
2008 Q4	0,00%	0,00%	0,00%	0,00%	0,00%
2009 Q1	2,06%	0,00%	0,00%	0,00%	0,00%
2009 Q2	0,00%	0,00%	1,12%	0,00%	1,09%
2009 Q3	0,00%	0,00%	0,00%	0,00%	0,00%
2009 Q4	0,00%	0,00%	0,00%	0,00%	0,00%
2010 Q1	0,00%	0,00%	0,00%	0,00%	0,00%
2010 Q2	0,00%	0,00%	0,00%	7,02%	1,11%
2010 Q3	0,00%	0,00%	0,00%	0,00%	0,00%

Source: own calculations in Matlab

Appendix 2: Annual probability of default in case of companies with the following stock symbols *SNP, DAFR, PTR, OIL, TEL*

	SNP	DAFR	PTR	OIL	TEL
2004 Q1	0,08%	0,00%	34,57%	25,26%	
2004 Q2	0,00%	0,00%	45,54%	0,00%	
2004 Q3	0,00%	0,00%	46,48%	0,00%	0,00%
2004 Q4	0,00%	32,27%	42,49%	0,00%	0,00%
2005 Q1	0,00%	0,00%	33,93%	0,00%	0,00%
2005 Q2	0,00%	14,24%	34,95%	0,00%	0,00%
2005 Q3	0,00%	0,00%	23,25%	0,00%	0,00%
2005 Q4	0,00%	9,27%	28,15%	0,00%	0,00%
2006 Q1	0,00%	0,00%	25,02%	0,00%	0,00%
2006 Q2	0,00%	18,45%	0,00%	0,00%	0,00%
2006 Q3	0,00%	0,00%	0,00%	0,00%	0,00%
2006 Q4	0,00%	6,75%	0,00%	0,00%	0,00%
2007 Q1	0,00%	0,00%	0,00%	0,00%	0,00%
2007 Q2	0,00%	7,28%	0,00%	0,00%	0,00%
2007 Q3	0,00%	0,00%	0,00%	0,00%	0,00%
2007 Q4	0,00%	1,11%	0,00%	0,00%	0,00%
2008 Q1	0,00%	1,88%	0,00%	0,00%	0,00%
2008 Q2	0,00%	2,14%	0,00%	0,00%	0,00%
2008 Q3	0,00%	3,86%	0,00%	0,00%	0,00%
2008 Q4	0,07%	18,75%	0,00%	12,25%	0,00%
2009 Q1	0,08%	26,47%	0,00%	59,61%	0,00%
2009 Q2	0,05%	30,30%	0,00%	0,00%	0,00%
2009 Q3	0,05%	5,25%	0,00%	0,00%	0,00%
2009 Q4	0,05%	6,10%	0,00%	0,00%	0,00%
2010 Q1	0,00%	3,89%	0,00%	0,00%	0,00%
2010 Q2	0,05%	5,31%	0,00%	0,00%	0,00%
2010 Q3	0,00%	5,07%	0,00%	0,00%	0,00%

Source: own calculations in Matlab

Appendix 3: Annual probability of default in case of companies with the following stock symbols AMO, AZO, OLT, ATB, BIO

	AMO	AZO	OLT	ATB	BIO
2003 Q1	75,24%				
2003 Q2	22,67%				
2003 Q3	12,08%				
2003 Q4	8,71%				
2004 Q1	10,71%	4,01%	65,49%	6,08%	
2004 Q2	16,22%	3,39%	59,63%	5,93%	
2004 Q3	6,38%	3,85%	49,27%	4,29%	
2004 Q4	6,93%	3,20%	79,16%	3,15%	
2005 Q1	5,09%	5,29%	63,30%	0,00%	
2005 Q2	9,98%	6,98%	55,27%	0,00%	
2005 Q3	7,70%	3,50%	0,41%	0,00%	
2005 Q4	9,96%	6,37%	0,41%	0,00%	0,00%
2006 Q1	12,34%	6,31%	0,38%	0,00%	0,00%
2006 Q2	16,17%	6,02%	0,36%	0,00%	0,00%
2006 Q3	8,15%	6,29%	0,47%	0,00%	0,00%
2006 Q4	6,58%	7,53%	0,46%	0,00%	0,00%
2007 Q1	8,88%	6,04%	0,56%	0,00%	0,00%
2007 Q2	7,48%	6,07%	0,22%	0,00%	0,00%
2007 Q3	15,60%	8,07%	0,17%	0,00%	0,00%
2007 Q4	83,69%	5,41%	56,13%	0,00%	0,00%
2008 Q1	90,12%	6,28%	43,27%	0,00%	0,00%
2008 Q2	30,14%	1,64%	41,27%	0,00%	0,00%
2008 Q3	89,57%	2,58%	38,75%	0,00%	0,00%
2008 Q4	32,20%	7,04%	35,68%	3,35%	0,00%
2009 Q1	18,92%	5,65%	33,27%	3,04%	0,00%
2009 Q2	31,51%	4,17%	30,23%	2,32%	0,00%
2009 Q3	33,68%	3,36%	27,55%	0,00%	0,00%
2009 Q4	0,00%	3,76%	25,16%	1,99%	0,00%
2010 Q1	0,00%	3,59%	45,56%	2,18%	0,00%
2010 Q2	1,11%	3,52%	24,23%	3,60%	0,00%
2010 Q3	0,00%	2,28%	16,26%	3,19%	0,00%

Source: own calculations in Matlab

Appendix 4: Annual probability of default in case of companies with the following stock symbols ALR, EPT, CMP, TBM, RRC

	ALR	EPT	CMP	TBM	RRC
2004 Q1	0,00%	35,51%	20,70%	0,00%	
2004 Q2	0,00%	43,44%	13,00%	22,65%	
2004 Q3	0,00%	35,26%	0,00%	0,49%	
2004 Q4	0,13%	16,62%	5,35%	0,00%	
2005 Q1	0,61%	57,61%	8,01%	84,22%	0,59%
2005 Q2	0,55%	18,03%	8,23%	95,87%	0,61%
2005 Q3	0,41%	69,83%	9,65%	91,27%	0,35%
2005 Q4	0,00%	31,25%	7,33%	80,61%	0,30%
2006 Q1	0,00%	15,87%	5,48%	74,33%	0,35%
2006 Q2	0,00%	24,82%	4,54%	0,00%	0,24%
2006 Q3	0,00%	68,63%	3,64%	0,00%	0,24%
2006 Q4	0,00%	75,49%	4,17%	0,00%	0,29%
2007 Q1	0,00%	51,87%	3,85%	0,00%	0,45%
2007 Q2	0,08%	3,03%	2,74%	0,00%	0,29%
2007 Q3	3,35%	4,01%	1,87%	0,00%	0,35%
2007 Q4	0,00%	6,46%	1,54%	0,00%	0,28%
2008 Q1	0,03%	8,01%	2,46%	3,46%	0,30%
2008 Q2	0,03%	49,43%	2,92%	4,14%	0,25%
2008 Q3	0,00%	36,55%	5,63%	15,29%	0,24%
2008 Q4	0,60%	76,48%	9,16%	22,02%	0,41%
2009 Q1	0,57%	17,13%	16,27%	19,29%	0,58%
2009 Q2	0,48%	48,38%	19,36%	21,52%	0,71%
2009 Q3	0,32%	64,03%	6,90%	19,68%	19,84%
2009 Q4	0,32%	64,44%	9,10%	26,17%	11,27%
2010 Q1	0,00%	62,10%	6,65%	12,79%	0,69%
2010 Q2	0,37%	71,89%	7,96%	21,96%	0,51%
2010 Q3	0,37%	68,33%	6,29%	23,13%	0,41%

Source: own calculations in Matlab