Credit Risk and Business Cycles

(A CreditPortfolioView Approach)

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Abstract: Credit risk, the dominant source of risk for banks, has been the focus of research in risk management analysis in the past several years. CreditPortfolioView (an econometric model) is a multifactor model that is used to simulate the joint conditional distribution of default probabilities for various sectors of the economy conditional on the value of macroeconomic factors. It is based on the observation that default probabilities are linked to economy. When the economy worsens, defaults increase; when the economy becomes stronger, defaults decrease. In other words, credit cycles follow business cycles closely.

Keywords: credit risk management, default risk modeling, macroeconomic conditions.

Jel Classification: C32, G20, G33

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* The views expressed in this paper are solely the responsibility of the author and should not be interpreted as reflecting the views of Marmara University.

1. Introduction

Since the Basel Committee on Banking Supervision (1996), measuring credit risk with proper tools gained significant importance and the modeling of credit portfolio risk became a major focus of academics and practice. Meanwhile, several methods have been developed to measure credit portfolio risk. These are CreditMetrics[2] by J.P. Morgan, CreditRisk^{+}[3] by Credit Suisse Financial Products, CreditPortfolioView[4] by Wilson and McKinsey and PortfolioManager[5] by KMV.

CreditMetrics is conceived for bond portfolios and is heavily relying on market values. Hence, credit risk arises not only from the danger of issuer default, but also from a potential (market) value loss due to a downgrade in the credit rating of the debtor. CreditRisk^{+} is a model that uses actuarial methods where only credit risk from defaults is considered and contrary to the asset value models potential reasons for a default have no significance. Default rates are assumed to be stochastic and are the risk drivers themselves. KMV's methodology defines a *distance to default*, which is the difference between the value of a company's assets and a certain liability threshold, such that if this quantity is negative, the company is bankrupt and will therefore default on its obligations.

McKinsey's CreditPortfolioView proposes a methodology to link macroeconomic factors to default probabilities which are modeled as a logit function. In this study, composite leading indicator, effective real exchange rate index and industrial production index are utilized as macroeconomic factors. Each factor is assumed to have an ARMA process of the order (p_i, q_i).

The main finding is that there is a strong relation between the state of the economy and default probabilities. Among the variables, composite leading indicator has the greatest effect on default probabilities. When composite leading indicator improves, default probabilities declines and vice versa. Among the four sectors (construction, textile, food and finance) analyzed defaults in the construction and textile sectors are affected greatly by the state of the economy.

The remainder of the paper is organized as follows. Section 2 offers a description of the data. In section 3 the econometric model, model estimates and forecasting outcomes are presented. Section 4 concludes and the appendix will be shown at the end of the paper.

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[2] See J.P. Morgan (1997).

[3] See Credit Suisse Financial Products (CSFP, 1997).

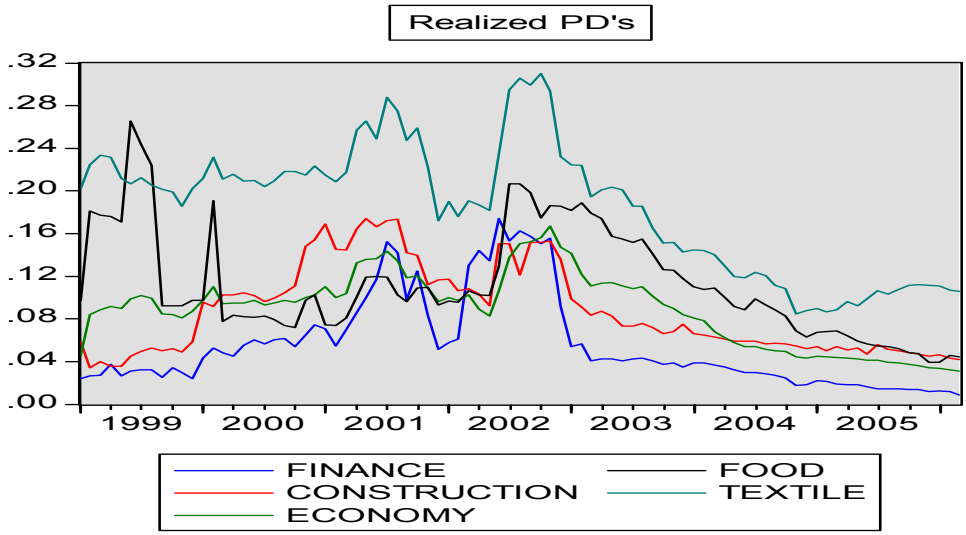
[4] See Wilson (1997a, 1997b, 1998).

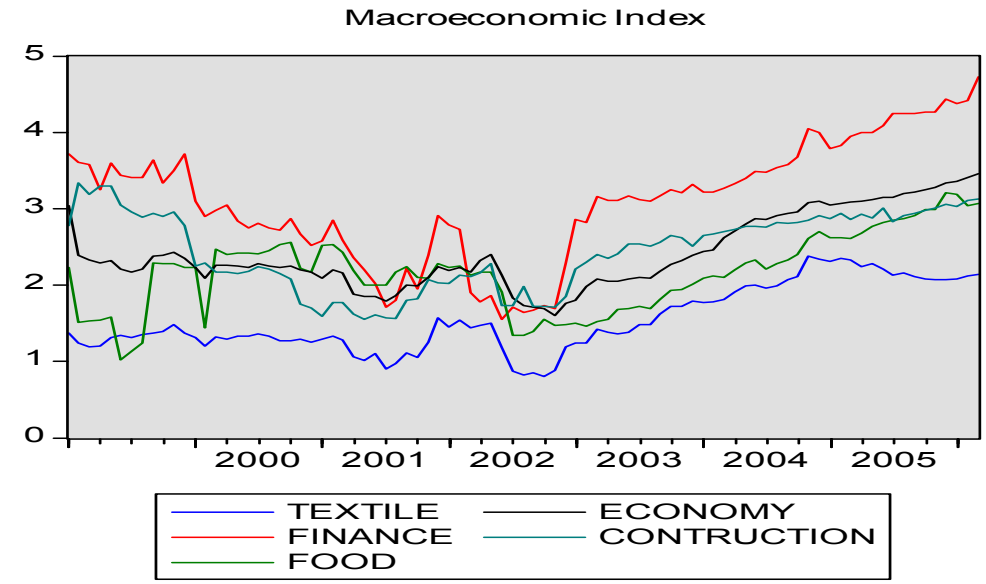
[5] See Kealhofer (1998).

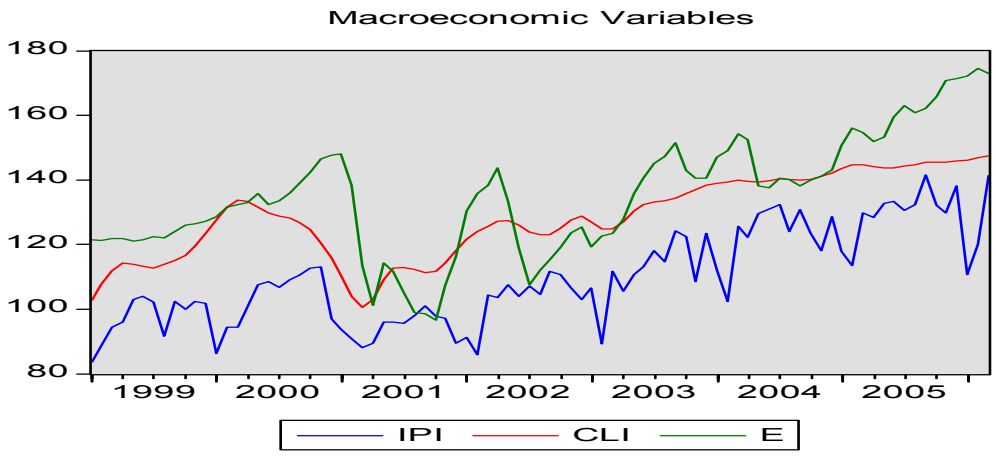
2. Data

The data set used consists of realized probability of defaults, a macroeconomic index which is a logit transformation of the default probabilities, composite leading indicator, effective real exchange rate index and industrial production index for the period of January, 1999 and March, 2006.

Realized probability of defaults is computed by dividing bad debt credits to cash credits which gained from the releases of the central bank on sector credits.







Effective real exchange rate index and industrial production index are more familiar concept than the composite leading indicator; hence, it is crucial to give details about the composite leading indicator. With the cooperation of OECD, the Central Bank of the Republic of Turkey has constructed a composite leading indicator for the Turkish economy with the aim of foreseeing the contraction and the expansion periods of the economic activity.
It consists of the following series:

- Production Amount of Electricity
- Discounted Treasury Auctions Interest Rate Weighted by the Amount Sold
- Import of Intermediate Goods
- CBRT Business Tendency Survey Question Related to the Stocks of Finished Goods
- CBRT Business Tendency Survey Question Related to the Amount of New Orders Received From Domestic Market
- CBRT Business Tendency Survey Question Related to the Export Possibilities
- CBRT Business Tendency Survey Question Related to the Employment

3. The econometric model, model estimates and forecasting outcomes

In this section, the econometric model will be explained in detail. Model estimates and their consistency will be argued and the strength of the forecasts will be analyzed.

3.1 The econometric model

Defaults probabilities are modeled as a logit function as follows:

$$\Pr ob_{j,t} = \frac{1}{1+e^{-Y_{j,t}}} \quad (1)$$

where $\Pr ob_{j,t}$ is the conditional probability of defaults in period t, for the sector j. $Y_{j,t}$ is the index value derived from a multifactor model described below. It is crucial to recognize that a logit transformation ensures that the probability takes a value between 0 and 1.

The macroeconomic index, which captures the state of the economy, is determined by the following multi-factor model:

$$Y_{j,t} = B_{j,0} + B_{j,1}X_{j,1,t} + B_{j,2}X_{j,2,t} + ... + B_{j,m}X_{j,m,t} + v_{j,t} \quad (2)$$

where $Y_{j,t}$ is the index value in period t for the j^{th} sector ; $B_{j,0}, B_{j,1}, B_{j,2}, ..., B_{j,m}$ are the coefficients to be estimated for the j^{th} sector; $X_{j,1,t}, X_{j,2,t}, ..., X_{j,m,t}$ are period t values of the macroeconomic variables for the j^{th} sector; and $v_{j,t}$ is the error term assumed to be independent of $X_{j,t}$ and identically normally distributed.

In the proposed implementation, each macroeconomic variable is assumed to follow univariate, autoregressive model of order 2 (AR2):

$$X_{j,i,t} = \gamma_{j,i,0} + \gamma_{j,i,1}X_{j,i,t-1} + \gamma_{j,i,2}X_{j,i,t-2} + e_{j,i,t} \quad (3)$$

where $X_{j,i,t-1}$, $X_{j,i,t-2}$ denote the lagged values of the macroeconomic variable $X_{j,i,t}$; $\gamma_{j,i,0}, \gamma_{j,i,1}$ and $\gamma_{j,i,2}$ are the coefficients to be estimated; the error term $e_{j,i,t}$ is assumed to be independent and identically distributed.

3.2 The model estimates

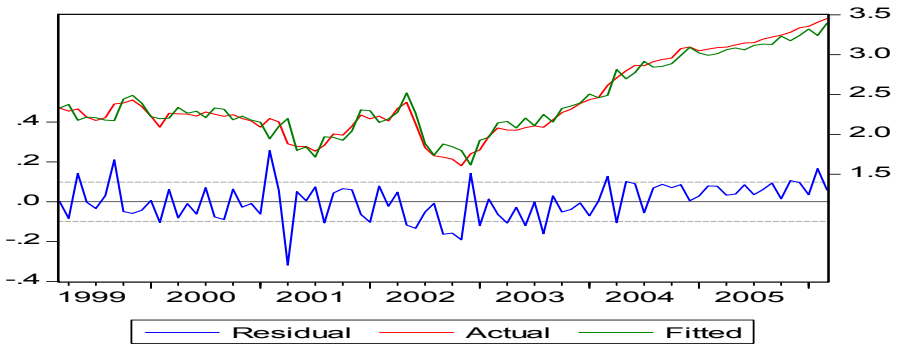
In this part, only the model estimates of the economy will be presented. Estimation outputs of sectors analyzed will be shown in Appendix.

Regressand		Y		
Regressors	Coefficient	Std. Error	t-Statistics	Probability
FCLI	0.016118	0.003130	5.149222	0.0000
FIPI	0.003642	0.002012	1.809901	0.0742
FE	0.004254	0.000825	5.155540	0.0000
C	-0.640642	0.468871	-1.366352	0.1758
MA(1)	1.470028	0.092265	15.93261	0.0000
MA(2)	1.689835	0.110235	15.32937	0.0000
MA(3)	1.371763	0.102602	13.36977	0.0000
MA(4)	0.586354	0.091849	6.383898	0.0000
R-squared	Adj.R-squared	D-W Statistics	F-Statistics	Prob (F-Stat.)
0.962148	0.958707	1.968560	279.6081	0.000000

The regressand Y is logistic transformation of the default probabilities. The regressors of FCLI, FIPI, FE and C are respectively the fitted values of composite leading indicator which has an ARMA (2, 2) process, fitted values of industrial production index which has an AR(2) process, fitted values of effective real exchange rate which has an AR(2) process, and C stands for constant. Moving average terms are introduced to clear the serial correlations in the residuals. The lag order is chosen based on Akaike information criterion.

Recognize that the coefficients of FCLI, FIPI and FE are positive and the coefficient of FCLI is about four times of the other coefficients. Thus, an increase in FCLI, FIPI and FE will lead to a rise in Y (a fall in the probability of defaults) and composite leading indicator has the greatest effect relative to other variables. The R-squared value of 0.962148 means that about 96 percent of the total variations in the regressand is explained by the regressors.

The graph of residual, actual and fitted values



As it is clear from the graph above, the fitted line has a good fit which is expected due to high R-squared value.

Correlogram of Residuals

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. | . |	. | . |	1	-0.006	-0.006	0.0029	
.*| . |	.*| . |	2	-0.081	-0.081	0.5814	
. | . |	. | . |	3	-0.028	-0.029	0.6521	
. | . |	. | . |	4	0.035	0.028	0.7617	
. | . |	. | . |	5	0.037	0.033	0.8895	
. | . |	. | . |	6	0.046	0.052	1.0917	
. |*. |	. |*. |	7	0.103	0.113	2.1052	
. |*. |	. |*. |	8	0.075	0.088	2.6411	
. | . |	. | . |	9	0.030	0.053	2.7315	
. |*. |	. |*. |	10	0.092	0.113	3.5668	
. | . |	. | . |	11	-0.019	-0.012	3.6031	
. | . |	. | . |	12	-0.010	-0.006	3.6132	

It seems form the correlogram above, the residuals exhibits no serial correlation. But, to formally decide we need to check Breusch-Godfrey Serial Correlation LM test.

Serial Correlation LM Test

Test Statistics	Coefficient	P-value	Decision
F-statistics	0.5622	0.8628	No S.C.[6]
Obs*R-squared	8.9419	0.7079	No S.C.

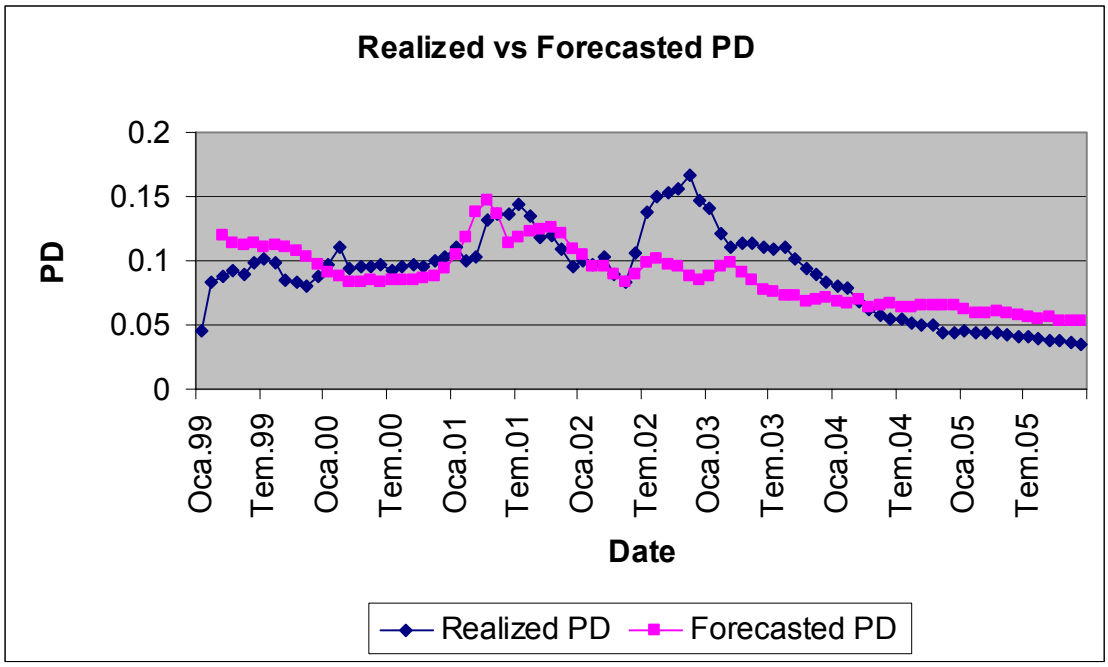
As the diagnostics support, the model estimates are robust.

3.3 Forecasts

In this part, the in-sample forecast of January, 1999- December, 2005 and the out-of-sample forecast of January, 2006 and March, 2006 will be presented.

[6] No S.C. means there is no serial correlation in the residuals based on Breusch- Godfrey Serial Correlation LM Test.

In–sample forecast;



As it is clear from the chart above, Forecasted probability of defaults catches the trend in realized probability of defaults.

Out–of-sample forecast;

Regressand	Regressors	Coefficients
Y	FCLI	0.0157
	FIPI	0.0036
	FE	0.0051
	C	-0.6613

	Realized		Forecast 1		Forecast 2		Forecast 3	
Date	Y	PD	Y	PD	Y	PD	Y	PD
Jan,06	3.3564	0.0337	2.8008	0.0573	2.5677	0.0713	3.0243	0.0463
Feb,06	3.407	0.0321	2.8666	0.0538	2.8666	0.0538	2.8666	0.0538
Mar,06	3.4533	0.0307	2.9785	0.0484	2.9785	0.0484	2.9785	0.0484

Forecast 1 is done using the coefficients of the regression above, which is estimated for in-sample forecast. Forecast 2 is made under the assumption that the value of composite leading indicator falls, once-and-for-all, by 10 percent in January 2006 relative to its value in December 2005 and Forecast 3 is done

under the assumption that the value of composite leading indicator increases, once-and-for-all, by 10 percent in January 2006 relative to its value in December 2005.

Based on the results above, an increase in the composite leading indicator which means economy is getting stronger lead to a decline in the probability of defaults and a decrease in the composite leading indicator which means economy shrinks increases the probability of defaults in the economy.

4. Conclusion

As has been shown in this paper, CreditPortfolioView is a multifactor model which captures the state of the economy. The driving variable in the model utilized is the composite leading indicator, as shown empirically. The improvement in the composite leading indicator leads to a decline in the probability of defaults and deterioration leads to an increase in the probability of defaults.

Among the four sectors analyzed, construction and textile are substantially sensitive to the state of the economy. As, economy worsens the defaults in these sectors increase and, as it gets stronger, the defaults decrease. However, for other sectors namely food and finance, the state of the economy has little effect on the defaults realized in these sectors. In other words, the defaults in food and finance are explained by other factors than the macroeconomic ones. Hence, the model developed here is a good candidate to explain the defaults in the construction and textile sector.

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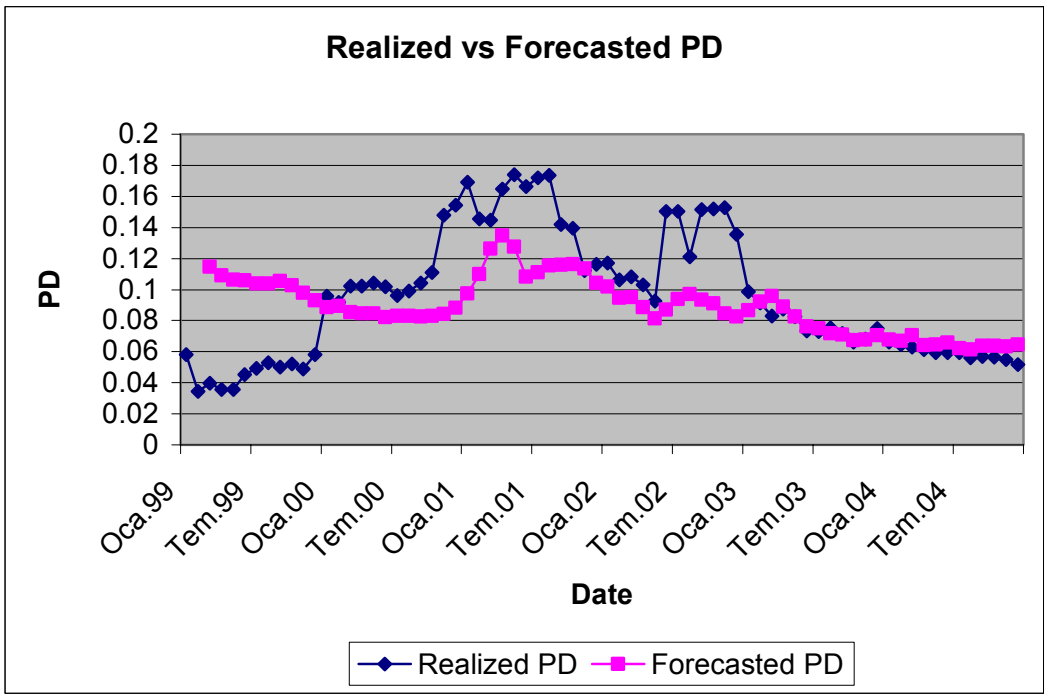
Appendix

In this part, Estimation outputs and forecast of some selected sectors in the economy will be presented. The first sector is the construction.

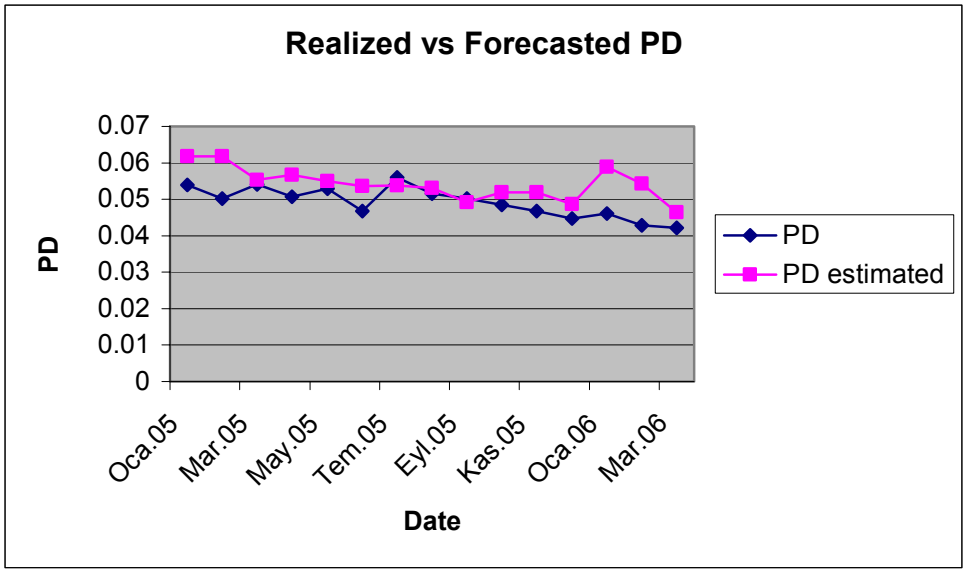
Model estimates for the construction sector is as the following:

Regressand		Y		
Regressors	Coefficient	Std. Error	t-Statistics	Probability
FCLI	0.010272	0.004377	2.347152	0.0215
FIPI	0.003483	0.001215	2.867215	0.0053
FE	0.008930	0.002977	2.999663	0.0036
C	-0.366725	0.655107	-0.559794	0.5772
MA(1)	1.189524	0.108689	10.94430	0.0000
MA(2)	1.381535	0.116229	11.88633	0.0000
MA(3)	1.105220	0.111054	9.952123	0.0000
MA(4)	0.330785	0.103705	3.189666	0.0021
R-squared	Adj.R-squared	D-W Statistics	F-Statistics	Prob (F-Stat.)
0.913616	0.905763	2.077359	116.3386	0.000000

The in-sample forecast of January, 1999- December, 2004



The out-of-sample forecast of January, 2005 and March, 2006

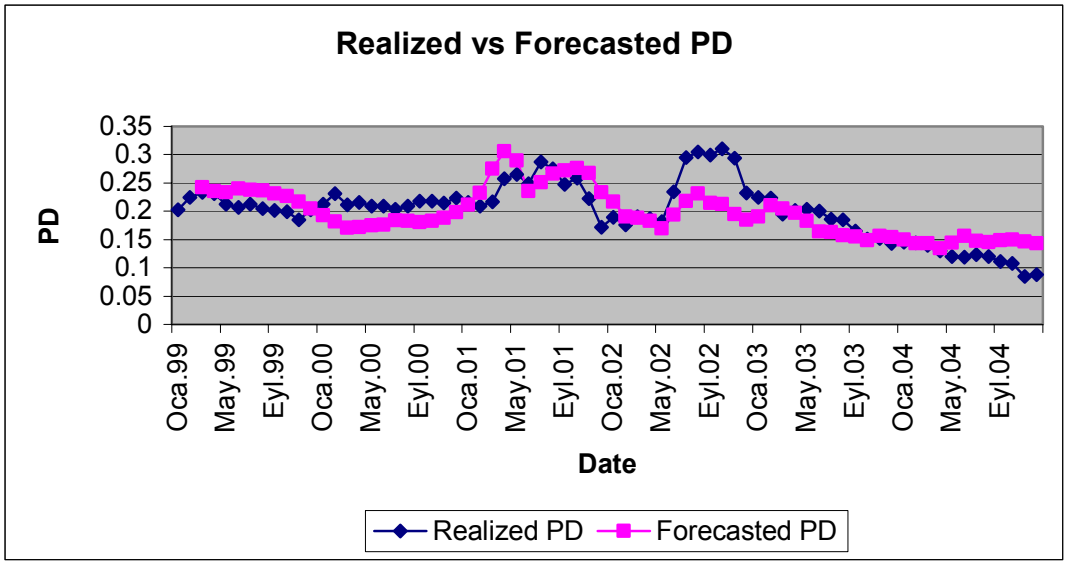


The second one is the textile.

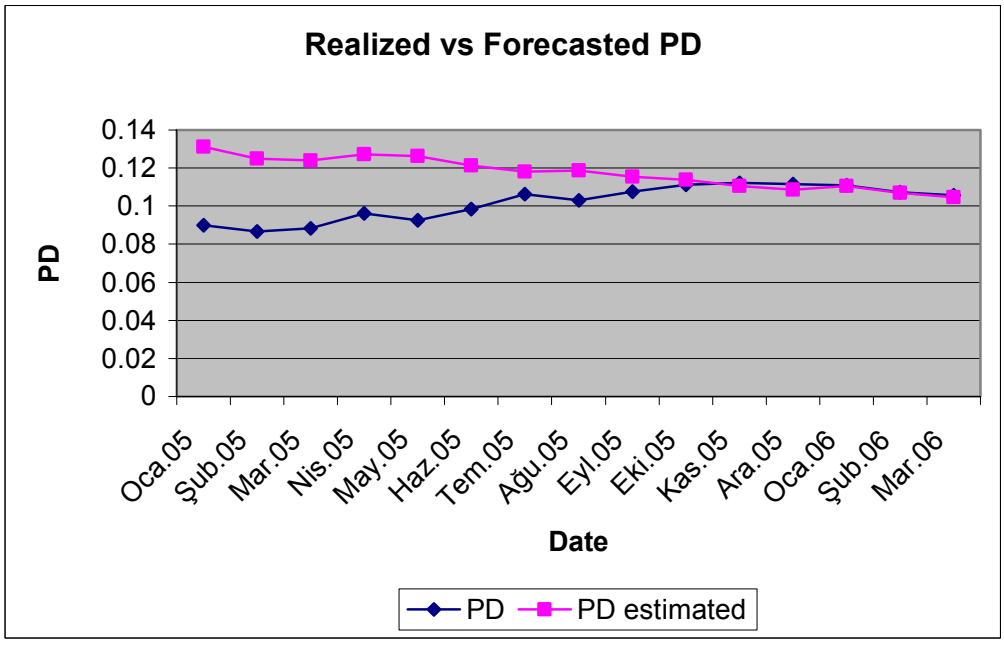
Model estimates for the textile sector is as the following :

Regressand		Y		
Regressors	Coefficient	Std. Error	t-Statistics	Probability
FCLI	0.010388	0.004101	2.553344	0.0133
FIPI	0.007052	0.001635	4.313329	0.0000
FE	0.006415	0.002875	2.231464	0.0286
C	-1.453549	0.450531	-3.226305	0.0018
MA(1)	1.176926	0.094058	12.51272	0.0000
MA(2)	0.978005	0.130054	7.520017	0.0000
MA(3)	0.883822	0.129072	6.847531	0.0000
MA(4)	0.555220	0.099187	5.597994	0.0000
R-squared	Adj.R-squared	D-W Statistics	F-Statistics	Prob (F-Stat.)
0.952394	0.948066	1.846789	220.0631	0.000000

The in-sample forecast of January, 1999- December, 2004



The out-of-sample forecast of January, 2005 and March, 2006

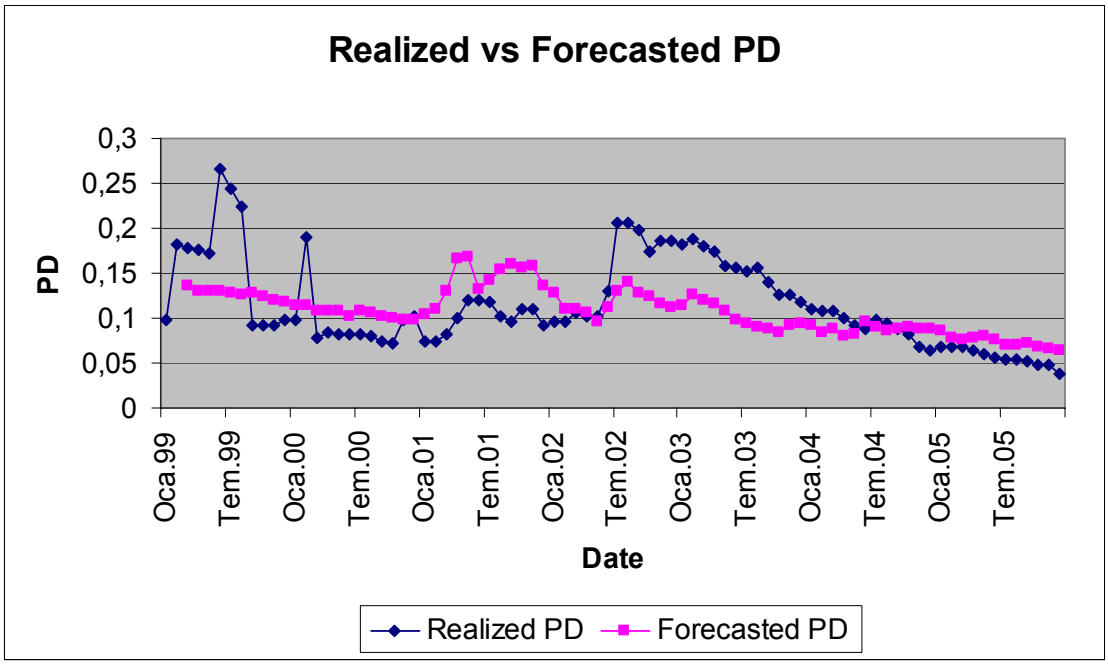


The third one is the food.

Model estimates for the food sector is as the following:

Regressand		Y		
Regressors	Coefficient	Std. Error	t-Statistics	Probability
FCLI	0.07165	0.008123	0.882002	0.0133
FIPI	0.009663	0.003400	2.842048	0.0000
FE	0.004192	0.006221	0.673854	0.0286
C	-0.525297	0.885156	-0.593452	0.0018
MA(1)	0.941570	0.113550	8.292123	0.0000
MA(2)	0.898691	0.146499	6.134449	0.0000
MA(3)	0.743922	0.161163	4.615974	0.0000
MA(4)	0.429647	0.150635	2.852234	0.0000
MA(5)	-0.263410	0.112533	-2.340736	0.0203
R-squared	Adj.R-squared	D-W Statistics	F-Statistics	Prob (F-Stat.)
0.952394	0.948066	1.846789	220.0631	0.000000

The in-sample forecast of January, 1999- December, 2005



The out-of-sample forecast of January, 2006 and March, 2006

Regressand	Regressors	Coefficients
Y	FCLI	0.0157
	FIPI	0.0036
	FE	0.0051
	C	-0.6613

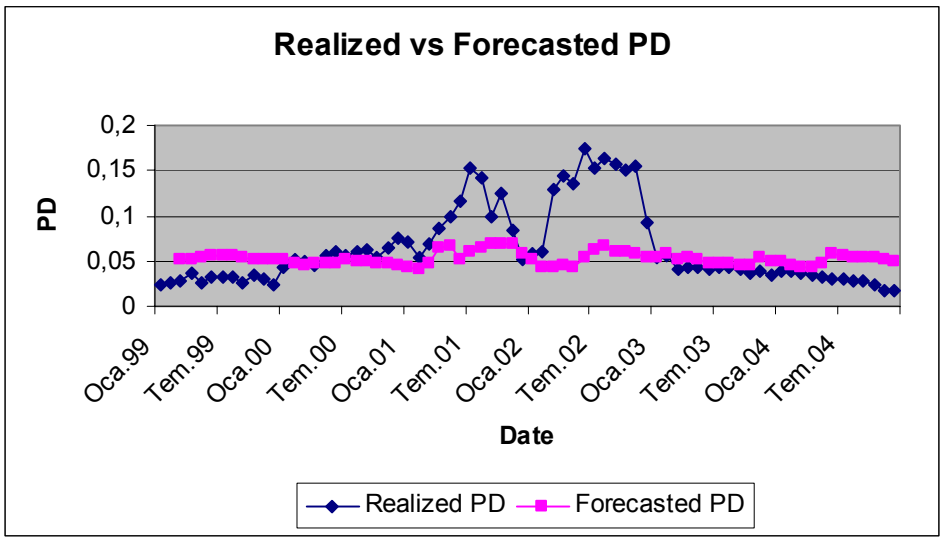
	Realized		Forecast	
Date	Y	PD	Y	PD
Jan,06	3.1897	0.0396	2.6221	0.0677
Feb,06	3.0429	0.0455	2.6865	0.0638
Mar,06	3.0665	0.0445	2.7572	0.0597

The last one is finance.

Model estimates for the finance sector is as the following:

Regressand		Y		
Regressors	Coefficient	Std. Error	t-Statistics	Probability
FCLI	0.020763	0.007481	2.775.522	0.0071
FIPI	0.009836	0.002050	4.797.837	0.0000
FE	-0.006221	0.001631	-3.815.012	0.0003
C	-0.202920	0.931079	-0.217941	0.8281
MA(1)	1.511.563	0.107719	1.403.250	0.0000
MA(2)	1.387.936	0.189106	7.339.469	0.0000
MA(3)	1.465.208	0.229681	6.379.305	0.0000
MA(4)	1.281.640	0.274480	4.669.349	0.0000
MA(5)	1.375.490	0.302428	4.548.156	0.0000
MA(6)	0.855542	0.330100	2.591.763	0.0116
MA(7)	0.683816	0.325223	2.102.603	0.0392
MA(8)	0.738875	0.292462	2.526.401	0.0138
MA(9)	0.665669	0.265503	2.507.197	0.0145
MA(10)	0.806217	0.217769	3.702.169	0.0004
MA(11)	0.789604	0.178213	4.430.680	0.0000
MA(12)	0.430745	0.103846	4.147.938	0.0001
R-squared	Adj.R-squared	D-W Statistics	F-Statistics	Prob (F-Stat.)
0.957915	0.948766	1.911235	104.7016	0.000000

The in-sample forecast of January, 1999- December, 2004



The out-of-sample forecast of January, 2005 and March, 2006