

Stata User Group Meeting

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Impact of credit ratings in crisis-hit countries
- an application with Markov Chains

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Introduction

- ▶ Credit rating agencies influence the access of governments to capital inflows of institutional investors.
- ▶ 'Sovereign ceiling' - private-sector issuers of debt very rarely obtain a higher credit rating than their sovereign's.
- ▶ Credit rating agencies have therefore a huge influence on the success of all issuances of debt in the world.
- ▶ We investigate if this influence reaches the perception of investors in the short run with a consequent impact in the stock market.

In the present study

- ▶ We develop a model in order to investigate if changes in a sovereign's credit rating affect that country's stock market index.
- ▶ We use weekly stock market's data to construct a five-class homogeneous Markov Chain, measuring the probabilities of transition to each class.

	Class 1	Class 2	Class 3	Class 4	Class 5
Class 1	p11	p12	...	...	p15
Class 2	p21	p22	...	...	p25
Class 3	...	...	...	...	...
Class 4	...	...	...	...	...
Class 5	p51	p52	...	...	p55

In the present study

- ▶ An ordered choice model is used to model the behaviour of the stock market index and estimate the transition probabilities matrix.
- ▶ For each line (same state of origin), the index can only transition into one of the 5 possible states, with total probability one.

	Class 1	Class 2	Class 3	Class 4	Class 5
Class 1	p11	p12	p15
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Class 3
Class 4
Class 5	p51	p52	p55

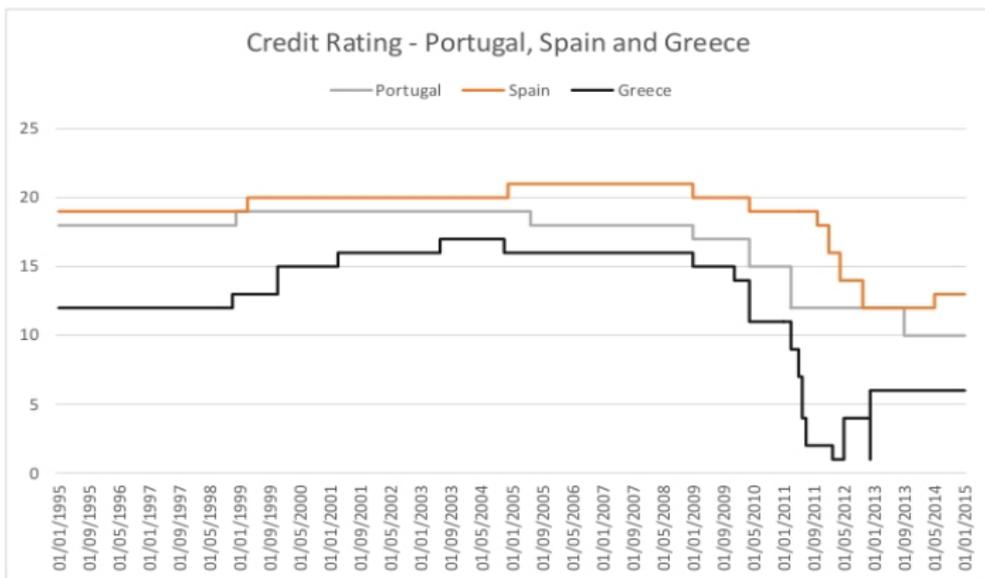
General framework

Methodology: based on ordered choice probit models [[oprobit](#), [oglm](#)].

Illustration: using the weekly value of stock market indices of three European and two Asian countries, with the corresponding sovereign credit ratings issued by Standard & Poor's, between 2009-2014 for European countries and 1997-2003 for Asian countries.

Results: suggest that credit ratings have a significant impact in the European countries considered, but not quite so for the Asian countries.

Standard & Poor's credit rating for European countries



A model for the class of a stock market index

- ▶ Let y^* be the value of the stock market index at a certain point in time.
- ▶ Suppose that y^* is a random variable conditional on explanatory variables \mathbf{x}

$$y^* = \mathbf{x}\beta + e$$

where $e|\mathbf{x}$ follows a standard Normal distribution.

- ▶ Regressors include previous values of the stock index, sovereign credit ratings, GDP values and interest rate announced by the ECB (in the case of European countries).

A model for the class of a stock market index

- ▶ Let $\alpha_1 < \alpha_2 < \dots < \alpha_j$ be specific cut points and define the stock market index classes (y) as follows

$$y = 1 \quad \text{if } y^* \leq \alpha_1 \quad (\text{low})$$

$$y = 2 \quad \text{if } \alpha_1 < y^* \leq \alpha_2 \quad (\text{medium-low})$$

$$y = 3 \quad \text{if } \alpha_2 < y^* \leq \alpha_3 \quad (\text{medium})$$

$$y = 4 \quad \text{if } \alpha_3 < y^* \leq \alpha_4 \quad (\text{medium-high})$$

$$y = 5 \quad \text{if } y^* > \alpha_4 \quad (\text{high})$$

- ▶ Constants α_j have been obtained by dividing the range of the index y^* in five equally spaced intervals.

A model for the class of a stock market index

- ▶ Given the standard normal assumption for e , we derive the conditional distribution of y given \mathbf{x} by computing each response probability:

$$\Pr(y = 1|\mathbf{x}) = \Pr(y^* \leq \alpha_1|\mathbf{x}) = \Pr(\mathbf{x}\beta + e \leq \alpha_1|\mathbf{x}) = \Phi(\alpha_1 - \mathbf{x}\beta)$$

$$\Pr(y = 2|\mathbf{x}) = \Pr(\alpha_1 < y^* \leq \alpha_2|\mathbf{x}) =$$

$$= \Pr(\alpha_2 - \mathbf{x}\beta) = \Phi(\alpha_2 - \mathbf{x}\beta) - \Phi(\alpha_1 - \mathbf{x}\beta)$$

⋮

$$\Pr(y = 5|\mathbf{x}) = \Pr(y^* > \alpha_4|\mathbf{x}) = 1 - \Phi(\alpha_4 - \mathbf{x}\beta)$$

- ▶ The parameters α and β can be estimated by maximum likelihood with $p_{ij} = \Pr(y_i = j)$.

Ordered Probit model

- ▶ With two observations of an index in two subsequent periods, we can define the transition probability between classes, considering the class of origin - in period one, and the class in period 2 (y).
- ▶ The ordered probit model will allow estimation of $\Pr(y = j|\mathbf{x})$ that is the probability of transition into class j in period 2, starting from the class specified in vector \mathbf{x} .
- ▶ As an illustration, the probability of an index attaining class 5 is specified as a function of regressors \mathbf{x} :
$$\Pr(y = 5|\mathbf{x}) = \Pr(y^* > \alpha_4|\mathbf{x}) = 1 - \Phi(\alpha_4 - \mathbf{x}\beta)$$
where Φ is the cdf of a standard Normal variable, and β the regression parameters.

Choice of regressors

- ▶ Class of Origin - index class in the previous period
- ▶ Credit Rating issued by Standard & Poor's
- ▶ GDP series published by OECD
- ▶ ECB - European Central Bank interest rate (European countries only)

Results of the Ordered Probit models - Partial Effects

Portugal	Class 1	Class 2	Class 3	Class 4	Class 5
Class of Origin	-0.157***	-0.0447***	0.0155	0.0454***	0.141***
Rating	-0.0159**	-0.00452*	0.00157	0.00459**	0.0143***
GDP	-0.00456*	-0.00130	0.000451	0.00132	0.00409*
ECB	0.0137	0.00389	-0.00135	-0.00396	-0.0123

Spain	Class 1	Class 2	Class 3	Class 4	Class 5
Class of Origin	-0.114***	-0.113***	-0.0133**	0.0906***	0.150***
Rating	-0.00682**	-0.00677**	-0.000797	0.00541**	0.00898**
GDP	-0.000378	-0.000375	-4.42e-05	0.000300	0.000498
ECB	0.0579**	0.0575***	0.00677	-0.0460**	-0.0762***

Greece	Class 1	Class 2	Class 3	Class 4	Class 5
Class of Origin	-0.149***	0.116***	-0.0153	-0.0212*	0.0694***
Rating	-0.0245***	0.0191***	-0.00252	-0.00348*	0.0114***
GDP	-0.00729***	0.00568***	-0.000747	-0.00103	0.00339***
ECB	0.0955	-0.0744	0.00979	0.0135	-0.0444

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Results of the Ordered Probit models - Partial Effects

South Korea	Class 1	Class 2	Class 3	Class 4	Class 5
Class of Origin	-0.147***	-0.0982***	0.0202	0.0770***	0.148***
Rating	0.00607	0.00407	-0.000835	-0.00319	-0.00611
GDP	-0.000123**	-8.27e-05**	1.70e-05	6.48e-05**	0.000124*

Indonesia	Class 1	Class 2	Class 3	Class 4	Class 5
Class of Origin	-0.0919***	-0.229***	0.119***	0.0932***	0.109***
Rating	0.000778	0.00194	-0.00101	-0.000789	-0.000925
GDP	-6.59e-05	-0.000164	8.52e-05*	6.68e-05	7.84e-05

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Results of the Ordered Probit models - Partial Effects

- ▶ Class of Origin - Statistically significant in all countries, especially for extreme classes. Supports the argument that stock market indices are basically AR(1) processes.
- ▶ Credit Rating - Statistically significant for European countries in the recent sovereign debt crisis. Asian markets seem immune to alterations of the sovereign's credit rating.
- ▶ GDP - Only relevant for Greece and South Korea.
- ▶ ECB - Only relevant for Spain.

Ordered Probit: Estimated transition probabilities - Portugal

Estimated transition probabilities at means

Portugal	Class 1	Class 2	Class 3	Class 4	Class 5
Class 1	0.709***	0.290***	0.000197	7.27e-09	0
Class 2	0.0380**	0.850***	0.111***	0.000418	5.61e-11
Class 3	2.06e-05	0.134***	0.711***	0.155***	1.87e-05
Class 4	6.50e-11	0.000297	0.0944***	0.869***	0.0362**
Class 5	0	4.19e-09	0.000137	0.298***	0.702***

Ordered Probit: Estimated transition probabilities at 10th and 90th percentil of Credit Rating - Portugal

Estimated transition probabilities at 10th percentil of Credit Rating (BBB-)

Portugal	Class 1	Class 2	Class 3	Class 4	Class 5
Class 1	0.822***	0.178***	4.16e-05	7.60e-10	0
Class 2	0.0819***	0.865***	0.0527***	9.75e-05	0
Class 3	0.000104	0.242***	0.678***	0.0794**	3.27e-06
Class 4	8.41e-10	0.00129	0.181***	0.804***	0.0142
Class 5	0	4.87e-08	0.000631	0.449***	0.550***

Estimated transition probabilities at 10th percentil of Credit Rating (A+)

Portugal	Class 1	Class 2	Class 3	Class 4	Class 5
Class 1	0.378**	0.619***	0.00347	7.67e-07	0
Class 2	0.00430	0.645***	0.344**	0.00639	1.14e-08
Class 3	3.82e-07	0.0266	0.542***	0.431***	0.000533
Class 4	0	1.07e-05	0.0160	0.814***	0.170***
Class 5	0	0	4.10e-06	0.0868**	0.913***

Conclusions

- ▶ This study suggests that sovereign credit ratings were relevant variables in the performance of European countries' stock exchange during the crisis period in study.
- ▶ The same methodology in a different context (South Korea and Indonesia during the East Asian crisis) failed to produce similar results.
- ▶ **Possible Extension:** To construct a binary choice model using a probit model. Given the stock market in a given period and knowing the impact of other variables, should we buy or sell?