UNIVERSITY OF IOANNINA
DEPARTMENT OF ECONOMICS

MACROECONOMIC RISK ASSESSMENT
A THRESHOLD APPROACH

Doctoral Dissertation

by **Georgios Sarigiannidis**

IOANNINA 2017

Υποψήφιος Διδάκτορας : Σαρηγιαννίδης Γεώργιος, Τμήμα Οικονομικών Επιστημών, Πανεπιστήμιο Ιωαννίνων.

Θέμα Διατριβής : Macroeconomic risk assessment – A threshold approach.

ΤΡΙΜΕΛΗΣ ΕΠΙΤΡΟΠΗ

Επιβλέπων
Χατζηνικολάου Δημήτριος, Αναπληρωτής Καθηγητής, Τμήμα Οικονομικών Επιστημών, Πανεπιστήμιο Ιωαννίνων.

Μέλη
Σίμος Θεόδωρος, Αναπληρωτής Καθηγητής, Τμήμα Οικονομικών Επιστημών, Πανεπιστήμιο Ιωαννίνων.

Νικήτας Πιττής, Καθηγητής του Τμήμα Χρηματοοικονομικής & Τραπεζικής, Διοικητικής, Πανεπιστήμιο Πειραιώς.

ΕΠΤΑΜΕΛΗΣ ΕΞΕΤΑΣΤΙΚΗ ΕΠΙΤΡΟΠΗ

Αντζουλάτος Άγγελος, Καθηγητής, Τμήμα Χρηματοοικονομικής & Τραπεζικής Διοικητικής, Πανεπιστήμιο Πειραιώς.

Απέργης Νικόλαος, Καθηγητής, Τμήμα Χρηματοοικονομικής & Τραπεζικής Διοικητικής, Πανεπιστήμιο Πειραιώς.

Νούλας Αθανάσιος, Καθηγητής, Τμήμα Λογιστικής & Χρηματοοικονομικής, Πανεπιστήμιο Μακεδονίας.

Παπαδόπουλος Συμεών, Επίκουρος Καθηγητής, Τμήμα Λογιστικής & Χρηματοοικονομικής, Πανεπιστήμιο Μακεδονίας.

Πιττής Νικήτας, Καθηγητής, Τμήμα Χρηματοοικονομικής & Τραπεζικής Διοικητικής, Πανεπιστήμιο Πειραιώς.

Συμεωνίδης Σπυρίδων, Αναπληρωτής Καθηγητής, Τμήμα Οικονομικών Επιστημών, Πανεπιστήμιο Ιωαννίνων.

Χατζηνικολάου Δημήτριος, Αναπληρωτής Καθηγητής, Τμήμα Οικονομικών Επιστημών Πανεπιστήμιο Ιωαννίνων.

ACKNOWLEDGMENTS

I am grateful to my major supervisor, Associate Professor Dimitris Hatzinikolaou. This work would have never been made possible without his help. With his excellent academic background he provided me with the confidence that the findings of this study were always lying on a solid scientific basis. I would like to express my sincere gratitude to him, for keeping me on track and for his patience and support. I would also like to thank all the members of the examination committee for their constructive comments during the thesis defense, which improved the final version of the thesis substantially. I especially thank Professor Angelos Antzoulatos for his time and effort to help me improve the thesis. Last, but not least, I would like to thank my family for their endless support.

ABSTRACT

The government bond spread, which reflects the associated risk of default, has become a leading economic variable after the recent financial crisis. Using a two-regime model, a high-spread and a low-spread regime, and two panel data sets, I investigate the influence on the spread of macroeconomic and quality-of-institutions variables, namely, the debt-to-GDP ratio, the rate of inflation, the rate of growth of real GDP, the primary surplus, the rate of unemployment, public investment, a risk-free interest rate (to capture shocks in the global economy), control of corruption, and government effectiveness. I define the two regimes by including a threshold value in the spread function, in accordance with the perceived fair value of the spread as a reference point. I assume that the decision maker may exhibit not only risk-averse, but also risk-seeking behavior, and I have introduced his/her preferences in the context of winning or losing. I have defined the threshold on the basis of credit ratings, namely, as the average of the associated rating class. Using annual data from a panel of 11 Eurozone countries and from another of 32 OECD countries, I estimate a log-linear equation for the spread with both fixed country-specific and time effects, as well as a nonlinear equation with partial adjustment with fixed country-specific effects only. Our empirical findings suggest that the effects of the explanatory variables on the spread are regime-dependent, since the regression coefficients differ in the two regimes. The estimated coefficients of the inflation rate, the real GDP growth rate and the unemployment rate are statistically significant in both regimes and robust to the various approaches used. Contrary to what has been found in the literature, however, the primary surplus is significant only in the low-spread regime, implying that it matters only when the spreads are lower than or equal to the reference point, whereas

the debt-to-GDP ratio is not significant. Taken on its face value, this finding has an interesting implication for the policies applied to the case of the Greek crisis, where the primary surplus and the debt-to-GDP ratio played a pivotal role, despite the fact that the spread was above the fair value. Thus, the "rescue program" for Greece needs to be reconsidered. The finding that the sizes of the coefficients of the explanatory variables are larger in the high-spread than in the low-spread regime is consistent with our assumption that a risk-seeking decision maker has inelastic demand for loans and ends up paying a higher spread than a risk-averse decision maker. For if a policy maker borrows when the spreads are above the "fair" value, knowing that this additional demand for funds will increase the spread by a lot, he/she behaves as a risk-seeking person.

ΠΕΡΙΛΗΨΗ

Η πρόσθετη απόδοση κινδύνου (spread), η οποία εμπεριέχεται στην απόδοση των κρατικών ομολόγων, αντικατοπτρίζει τον κίνδυνο χρεωκοπίας μιας χώρας και αποτελεί την κύρια οικονομική μεταβλητή στην μακροοικονομική διαχείριση κινδύνου χώρας, ιδιαίτερα μετά την πρόσφατη οικονομική κρίση. Χρησιμοποιώντας ένα υπόδειγμα δύο καταστάσεων, υψηλών και χαμηλών spreads, ερευνώ την επίδραση στο spread ενός νέου συνόλου μεταβλητών, κυρίως μακροοικονομικών, αλλά και μεταβλητών ποιότητας των θεσμών, συγκεκριμένα, του λόγου χρέους προς ΑΕΠ, του ρυθμού πληθωρισμού, του ρυθμού αυξήσεως του πραγματικού ΑΕΠ, του πρωτογενούς πλεονάσματος της Κεντρικής Κυβέρνησης, του ποσοστού ανεργίας, ενός επιτοκίου χωρίς κίνδυνο, το οποίο μπορεί να αντανακλά διαταραχές στην παγκόσμια οικονομία, των δημοσίων επενδύσεων, του ελέγχου της διαφθοράς και της κυβερνητικής αποτελεσματικότητας. Εισάγω την έννοια του «δίκαιου» περιθωρίου απόδοσης κινδύνου (“fair” spread), το οποίο αποτελεί το σημείο αναφοράς στην διαδικασία λήψης αποφάσεων, δημιουργώντας δύο καταστάσεις, μια όταν το spread είναι μεγαλύτερο από αυτή την τιμή και μια όταν είναι μικρότερο ή ίσο με αυτή. Οι προτιμήσεις του λήπτη αποφάσεων δεν χαρακτηρίζονται μόνο από αποστροφή προς τον κίνδυνο, αλλά και από επιζήτηση αυτού. Επιπλέον, θεωρώ ότι οι αποφάσεις δεν λαμβάνονται μόνο στα πλαίσια της έκθεσης στον κίνδυνο, αλλά και στο δίπτυχο κερδίζω-χάνω, ανάλογα με την τιμή των κρατικών ομολόγων. Ως σημείο αναφοράς (threshold), ορίζω τη μέση τιμή των spreads των χωρών που ανήκουν στην ίδια πιστοληπτική κατηγορία. Χρησιμοποιώντας δύο δεδομένα πάνελ, το ένα από 11 χώρες της Ευρωζώνης και το άλλο από 32 χώρες του ΟΟΣΑ, εκτιμώ μία εξίσωση για το spread, τόσο σε λογαριθμικά γραμμική μορφή με σταθερές επιδράσεις των χωρών

και των ετών (fixed country-specific and time effects), όσο και σε μη γραμμική μορφή με σταθερές επιδράσεις των χωρών μόνο, η οποία ενσωματώνει και το μηχανισμό της μερικής προσαρμογής (partial adjustment). Τα εμπειρικά αποτελέσματα δείχνουν ότι οι επιδράσεις των ερμηνευτικών μεταβλητών στο spread εξαρτώνται από το σε ποια κατάσταση βρίσκεται η οικονομία, σε «χαμηλά» ή σε «υψηλά» spreads, καθώς οι εκτιμήσεις των συντελεστών των παραπάνω ερμηνευτικών μεταβλητών είναι στατιστικά σημαντικές και διαφέρουν από κατάσταση σε κατάσταση. Σε επίπεδο χωρών Ευρωζώνης, οι συντελεστές του ρυθμού πληθωρισμού, του ρυθμού αυξήσεως του πραγματικού ΑΕΠ, και του ποσοστού ανεργίας είναι στατιστικά σημαντικοί σε όλες τις προσεγγίσεις που χρησιμοποιήθηκαν. Σε αντίθεση με την υπάρχουσα βιβλιογραφία, όμως, τόσο στο μη γραμμικό υπόδειγμα όσο και στο λογαριθμικά γραμμικό υπόδειγμα, ο λόγος του χρέους προς ΑΕΠ δεν βρέθηκε στατιστικά σημαντικός, ενώ το πρωτογενές πλεόνασμα βρέθηκε στατιστικά σημαντικό μόνο στην κατάσταση των χαμηλών επιτοκίων. Αυτό σημαίνει ότι η μεταβλητή αυτή επιδρά μόνο όταν το spread είναι μικρότερο από την «δίκαιη» τιμή του. Το εύρημα αυτό παρουσιάζει ιδιαίτερο ενδιαφέρον, καθώς οι πολιτικές που εφαρμόστηκαν στην διαχείριση της Ελληνικής κρίσης απαρτίζονταν ως επί το πλείστον από δημοσιονομικούς κανόνες, παρότι η χώρα βρίσκονταν σε καθεστώς υψηλών επιτοκίων, όπου το spread ήταν υψηλότερο από την «δίκαιη» τιμή του. Με βάση τα ανωτέρω, το «πρόγραμμα διάσωσης» που χρησιμοποιήθηκε στην Ελληνική περίπτωση χρήζει επαναπροσδιορισμού. Επιπροσθέτως, οι εκτιμήσεις των συντελεστών των παραπάνω μεταβλητών είναι μεγαλύτερες (κατ’ απόλυτη τιμή) σε καθεστώς υψηλών spreads, ένα εύρημα που είναι συνεπές με την υπόθεση ότι ένας risk-seeking λήπτης αποφάσεων έχει ανελαστική ζήτηση για δανεισμό και τελικά πληρώνει υψηλότερο spread. Συνεπώς, εάν αποφασίσει να δανειστεί γνωρίζοντας ότι θα τιμολογηθεί ακριβότερα, τότε αυτό μπορεί να θεωρηθεί ως ένδειξη risk-seeking συμπεριφοράς.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

1.1 A two-regime model for the spread

The recent financial crisis and the current situation in the global economy suggest that modern macroeconomic modeling and decision making have become more complex. The complexity of the global financial system, the Daedalus of rules and regulations and the access to complete information from all parties involved, created situations where the idea that a theory can be applied to every state of affairs seems unrealistic.

Imagine a married couple with tenured jobs searching for a loan to finance the acquisition of a house. It is fully informed about its financial status so it has an idea, based on the banking system and the competition, about the interest rate that the bank might charge it. It believes that its financial condition is sufficient for a loan of an amount, say K, with a “fair” interest rate of, say, 5%, which consists of the three-month Euribor,0,7%, plus the bank’s margin,4,3%, but is uncertain about the bank’s behavior. I assume, and this is important in this study, that there exists a “fair” spread for this loan that both parties are aware of. The question I want to answer is, What would be the couple’s response, given its financial condition, if the bank offers it an interest rate of a) 7%, which is 2 percentage points higher than the subjective “fair” rate, and b) 3,5%, which is 1,5 percentage points lower than the “fair” rate. Assume also that the couple derives utility from the spread. Furthermore, the couple may not be a traditional risk-averse decision maker, but might be risk seeking based on the circumstances and the available information. In the present study, the decision maker is the incumbent politician who wants to finance his/her government program by borrowing from the markets, which charge him/her an interest rate in accordance with the prevailing macroeconomic conditions.

Uncertainty is reduced via observation and information gathering. I assume that in a modern economy, both parties involved in a financial transaction are well informed because they gather information regarding their financial position. Based on the economic status of an individual, firm or country, I assume that there exists a "fair" spread, which is known to both parties and on which decisions are based. This process is called "reference dependence" in Kahneman and Tversky (1991, 1992). I incorporate this notion in my model. To my knowledge, it has not been used in the country-risk assessment macroeconomic literature. I claim that policymakers base their decisions on a reference point, which is the perceived "fair" 10-year government bond spread rate in relation to a set of macroeconomic variables. The reference point creates two regimes, the "high-spread" and the "low-spread" regime, so the model requires the presence of a threshold.

Fluctuations of yields and spreads have been studied in the literature using standard structural-break modeling, where the dummy variable takes on the value of zero for the period before the financial crisis and the value of one for the period after the crisis.

In the present study, I use a threshold approach and annual data from a panel of 11 Eurozone countries as well as from another panel of 32 OECD countries to test the two-regime hypothesis. The empirical results of this study suggest that it does matter what regime a country is in, both in terms of the global environment and its fiscal position. In particular, when the spread rates are below or equal to the "fair" level, bond yields are mainly influenced by the inflation rate, the real GDP growth rate, the unemployment rate, and the primary surplus. On the other hand, when the spread exceeds the "fair" level, the above variables are still significant, except for the primary surplus. This result is in sharp contrast with the literature, which suggests that markets pay more attention to the primary surplus and the debt-to-GDP ratio.

In the literature, there is some evidence that a threshold value exists. For instance, using a Markov switching model, Alexander and Kaeck (2008) showed that credit default swaps (CDS) display regime switching behavior. Intuitively, a threshold value exists when the perceived probability of default, from the lender's point of view, i.e., the capital markets, differs from that of the borrower's, i.e., the governments. Thus, in accordance with the literature on country risk, an increase in the probability of default, as perceived by lenders, causes the government bond spread to rise, thus a higher interest rate is charged for government borrowing. Whether this higher interest rate should be considered as a higher cost of borrowing will depend on the relationship between the probability of default as perceived by the lenders and that as perceived by the borrowers. In the case that the perceived probability of default is the same for lenders and borrowers, the higher spread charged to the specific country will not represent higher economic cost. On the other hand, as Harberger (1980) has postulated, if the probability of default perceived by lenders exceeds that perceived by borrowers, the fraction of the higher interest rate charged will represent a higher economic cost of borrowing from abroad.

To determine whether a threshold exists in the spread function, I start my analysis by proposing that the interest rate can be decomposed into the following components: (1) a risk-free rate, (2) a "fair" spread, and (3) a variable δ. If δ is zero, then the assessed risk spread is the "fair" one; otherwise, it reflects the presence of underestimation or overestimation (speculation) phenomena. This formulation is equivalent to the two-regime hypothesis.

It seems plausible to assume that the satisfaction derived from policy making can be considered independently of satisfaction derived from other activities, so I assume that the complete utility function of the policy maker is separable and concentrate on the sub-utility function associated with policy making. Further, I assume that the spread is the only argument in this sub-utility function, implying that successful macroeconomic policy making is reflected in a low spread, which provides the decision maker with utility, as borrowing is often crucial in the creation of wealth and consumption goods, and hence its cost is of great importance. This is an innovation, which generates insight about the mechanism that drives people's preferences under different levels of risk.

Thus, I introduce a sub-utility function of a policy maker who makes decisions relative to a reference point (the "fair" price or perceived price). This function depends on a set of macroeconomic and institutional variables that reflect the country's economic condition.

Governments generally seek credibility to ease their own access to credit. The government bond yield spread represents the risk premium relative to a benchmark government bond. In the present study, I have used various types of benchmarks, namely, the long-run interest rate of Germany, the Libor rate over the Euro, and a third benchmark, aimed for robustness checks and future work, which I have constructed and dubbed MINRFB. The latter chooses the Minimum Risk-Free Benchmark each year between the German interest rate, the Libor, and the 10-year US Treasury rate. The intuition is that the benchmark bond is considered "the" risk free asset, so by choosing the minimum of the three widely used risk free assets, I create the "most" risk free benchmark for every year, since the lower is the interest rate associated with a risk-free asset the lower is the risk associated with it. In the literature I have surveyed, I have not seen such a definition of the benchmark used to assess the spread related to each country. Professor Antzoulatos, member of the examination committee, criticized the use of this definition, however, on the grounds of the different currency and maturity of these benchmarks, so in the main results I use only the Libor over Euro, and relegate the empirical results involving the MINRFB in the Appendix.[1]

The selection of the variables in the spread function is important for this study. The empirical literature has explored a large set of explanatory variables to explain sovereign spreads. Following Edwards (1984), Feder (1977a, b), and others, I consider the spread as a function of the probability of default, which is itself a function of a set of macroeconomic and institutional indicators.

Next, I specify the threshold value in an ad-hoc manner. Although the markets, i.e. the lenders, are the ones that price economic entities, it is nevertheless in the hands of the policy maker, i.e. the borrower, to influence the spread by implementing the appropriate policies. Again, the borrower believes that his/her country should be priced based on its macroeconomic and institutional conditions which he/she can affect. The reference point is the level of the spread that he/she might change his/her decision to borrow or not. In the original version of the dissertation, I argued that the average spread, or the weighted average spread based on the GDP, of the year prevailing in the Eurozone countries is the reference point of the decision making process. These assumptions received criticism regarding their economic meaningfulness, however.[2] Therefore, I have used the credit rating

[1] In section 2.5, I attempt to justify the use of MINRFB.

[2] Professor Antzoulatos argued that using the average or the weighted average of the 10-year government bond spread of the countries in the panel has no economic meaning. From a statistical point of view, however, the notion of the average value is appealing and scientifically accepted, so I will keep using these notions in the empirical analysis for robustness purposes.

associated with every government, which is considered a non-controversial and well approved credit measure accepted from both parties, i.e. the borrower and the lender. I sort the countries depending on their credit rating, provided by Moody's, and divide them into blocks. As the "fair" value, I take the average spread of the associated rating class that each country belongs to each year. In this sense, country credit ratings are taken into account.[3] Thus, I consider two regimes, one above this value and the other equal to or below it, and aim to test whether the estimated coefficients differ in the two regimes.

After the selection of the variables and the threshold value, I have tested the hypothesis that a threshold value exists. The Eurozone countries are my main area of interest, so I have set up Data Set 1 for 11 Eurozone countries. To check the robustness of the results and to be able to make inferences for a greater group of countries, I have applied the same methodology to Data Set 2, which contains data from 32 OECD countries. I have used two major specifications of my estimating equation: (i) a log-linear specification, estimated by fixed and time effects methods, and (ii) a nonlinear specification with fixed effects only. In both cases, the results support the hypothesis of a threshold in the spread function, since the effects of the explanatory variables on the spread differ in the two regimes.

Finally, I have attempted to introduce a decision maker whose preferences may vary between risk aversion and risk seeking based on a reference point, the perceived-subjective fair price of the spread related to each country. I believe that the perception of gaining or losing relative to a reference point plays an important role in the decision making process, especially when the decision maker is a policymaker. In this sense, decisions are made based on gains and losses which are connected with

[3] I am indebted to Professor Antzoulatos for this definition.

risk loving or risk averting behavior. Furthermore, as mentioned in Kahneman and Tversky (1979, 1991, 1992), losses might loom larger than gains, which is the concept of loss aversion, which affects greatly human decisions. There exists a specific family of utility functions that exhibit such behavior, namely the sigmoid utility functions. The utility function is increasing *S*-shaped, namely steeper below the reference point than above it, and is convex below the reference point and concave above it; see Kahneman and Tversky (1992). However, the utility function that i propose in my model is decreasing, with exactly the opposite curvature, namely concave below the reference point and convex above it.

1.2 Motivation

The systematic rise in the government debt globally, in both developed and less developed countries, and the borrowing strategies that governments have followed, have given rise to concerns about the dangers that the handling of this situation may pose for the countries and for the functioning of the global financial system. Serious questions have arisen as to whether the governments have been borrowing too much or at too high interest rates, or perhaps both, regarding their financial position as reflected by their macroeconomic figures, and whether creditors, including the central banks, have overextended themselves. Furthermore, debt buyers offered large volumes of new and expensive credit to governments with not so promising macroeconomic indicators at a specific period, while the politicians in these countries kept on borrowing from the markets, despite the fact that they were fully aware of the unhealthy macroeconomic condition of their country. This created spurious expectations, since the payout of such loans was uncertain from the very beginning.

Motivated by the recent financial crisis, in the present study I attempt to research the following topics:

a) The traditional idea that an economic model can be applied to every situation, no matter what state we are in, may not be realistic, as modern risk theory and extreme value theory suggest. I believe that economic agents value their decisions relative to a reference point (or perhaps more than one), which is highly correlated with certain idiosyncratic characteristics.

b) What is the force that drives such decisions? Is it the perception of risk or the game of winning and losing? Following the prospect theory, I present a decision maker whose preferences are based on whether he is gaining or losing, given a set of constraints. I introduce a specific utility function, the *S*-shaped function, which changes shape relative to a reference point.

c) Which risk-free rate should be used, and how does this choice affect the results? The selection of the risk-free rate is important, as it reflects the impact of the fluctuations in the global economy. Note that although there exists a large literature on the selection of the most appropriate risk-free rate, this variable is absent in most of the models. In this study, I have used the long-run German interest rate as the risk-free interest rate.

d) Which benchmark asset should be used? The selection of the benchmark asset is crucial in computing the government bond spread. Again, there exists a large literature on this topic, which shows that even the most widely used benchmark bonds fluctuate greatly from year to year. Motivated by this part of the literature, I have plotted these benchmarks and I noticed that their evolution over time is quite similar, implying high correlation, despite the fact that their currency and maturity is different. By definition, the benchmark asset is the most risk-free asset. For the sake of completion, in order to choose the least risky asset every year, I define a new type of benchmark, used only for robustness checks, the one with the minimum interest rate from the set of the most widely used ones, so as to avoid possible misspecification in the spread function.

e) Is speculation present in the financial markets? The answer is yes, since there exists a difference between the lenders' pricing and the borrowers' perception of their credibility status. I argue, however, that this is not the point. The crucial question is not how the markets price economic entities and governments, but how politicians react during various pricing levels. This implies that at least one threshold value should be present in the decision-making process. The nature of this threshold value is directly related to the diptych of gaining or losing. From my point of view, a rational decision maker will base his/her decision to borrow or not on his/her financial status and on the level of the offered spread rate.

f) Is the pricing of government bonds nowadays, as reflected by the spread over a risk-free benchmark, regime-dependent and subject to threshold effects? Do market data support the hypothesis that a threshold value exists? This question is central in the present study.

g) Which variables influence the spread and what is their impact in each regime? Which estimation method is appropriate in estimating the spread equation?

h) Does the impact of the explanatory variables have any implications regarding preferences towards risk?

1.3 Structure of the study

The rest of this dissertation is organized as follows. In Chapter 2, I survey the existing literature on assessing government bond spreads and discuss the selection of the determinants of the spreads. I present bibliographic sources related to the definition of the risk-free rate as well as the benchmark selection. I analyze the existing framework and the recent developments in the field of regime switching models. Finally, I review the literature related to prospect theory and *S*-shaped utility function, which form the basis in the description of the preferences of the proposed decision maker.

In Chapter 3, I develop the theoretical model step by step. In the first place, I introduce the general framework of the decision makers' preferences, which imply reference dependence and the existence of threshold values in the process. Then I make an attempt to link the probability of default to the 10-year government bond spread, which is a function of macroeconomic indicators. The specification of the empirical model closes Chapter 3.

In Chapter 4, I use various econometric techniques to estimate and test the validity of the model, and in particular test the hypothesis that a threshold exists in the spread function. Then, I discuss the findings and compare them with those in the literature.

In Chapter 5, I summarize my finding and propose future steps.

CHAPTER 2: REVIEW OF THE LITERATURE

2.1 Introduction

The recent financial crisis and the anemic growth of the global economy that followed afterwards, was very didactic for the mechanisms that drive the international financial system and the ways that economic agents and governments interact. It might sound convenient to believe that the financial crisis triggered by the collapse of the subprime market in the United States was the root of the problem, but unfortunately it appeared that this was only the tip of the iceberg. The issue of the rapid rise of governmental debt was present decades ago, but it was well covered (hedged) either by temporary growth during periods of prosperity or by sophisticated and ambiguous methods from specific global entities of the financial system.

Debt servicing as well as the borrowing capacity of the country is undoubtedly a subject of great interest and concern for governments and international lending organizations and institutions. Quantitative knowledge of the determinants of the sovereign spread is essential for borrowing countries in designing policies which affect their determinants and consequently their credit availability and probability of default. The methods that the financial markets use to price government bonds and subsequently determine country risk spreads, require detailed analysis, as well the preferences of the decision makers, i.e., the politicians, who were responsible to decide whether to borrow or not. In this chapter, I discuss the literature related to the above topics as well the recent advances in modeling analogous problems.

2.2 The Utility function and the preferences of the decision maker

Since notions such as benefit, satisfaction or happiness cannot be measured directly, economists have introduced ways of representing utility as a function of measurable economic variables. Thus, I consider the government bond spread as the only variable in the utility function. Kydland and Prescott (1977), proposed the variables inflation and unemployment in the utility function. A similar approach can be found in Di Tella et al (2001). This is innovative and provides insight about the mechanism that drives people's preferences under different levels of risk. The assumption that the policy maker's utility function depends only on the spread is based on the idea that the spread can be thought of as an index of the economy's macroeconomic and institutional performance. This idea is consistent with our empirical model, where the spread is a function of macroeconomic and quality-of-institutions variables.

There is a specific family of utility functions that exhibit both convexity and concavity, the sigmoid utility functions. In order to capture this effect, Kahneman and Tversky (1992) introduce the following two-part power utility function:

$$u(x)=\begin{cases} u^{+}(x)=x^{a} & if\ \ x>0 \\ u^{-}(x)=-k(-x)^{b} & if\ \ x<0 \end{cases}, \qquad (1)$$

where x represents a gain or a loss and $k>1$ is a coefficient that captures the effect of loss aversion, indicating the fact that economic agents value losses more than gains. In this sense, the parameter k should reflect that the resulting value function is steeper for losses than for gains.

In an experiment, Kahneman and Tversky (1992) estimated the following values for the parameters: $a = b = 0.88$ and $k = 2.25$. Note that preference homogeneity is both necessary and sufficient to represent $u(x)$ as a function of this form. The value V of the lottery is evaluated as a weighted average of the following form:

$$V = \sum_{i \in gains} w_i^+ u^+(x_i) + \sum_{i \in losses} w_i^- u^-(x_i)$$

where the decision weights *w* are not the objective probabilities of the lottery, but are calculated by using the following functional form:

$$w^+(\pi) = \frac{\pi^c}{(\pi^c + (1-\pi)^c)^{1-c}}, \quad w^-(\pi) = \frac{\pi^d}{(\pi^d + (1-\pi)^d)^{1-d}}$$

With *c* estimated to be 0.61 and *d* to be 0.69. The decision weights are calculated as $w^{\pm} = w^{\pm}(\pi_i) - w^{\pm}(\pi_{i*})$, where π_{i*} is the probability of the outcomes that are strictly better (worse) than *i*, and π_i is the probability of all outcomes at least as good (bad) as *i*.

This utility function results from three influences – reference dependence, loss aversion, and diminishing sensitivity. As was noted in Section 1.1, “reference dependence” is the idea that value resides in gains and losses relative to a reference point, and not in total wealth. Loss aversion is the idea that a loss has greater value than a gain of an equal size. Diminishing sensitivity is the idea that the marginal values of gains and losses decrease as the gains and losses increase.

2.3 Government bond spreads and macroeconomic risk

The government’s ability and willingness to repay its debt both the principal and the interests on time, is a complex and demanding issue. The government bond spread, defined as the difference between the government bond yield and a risk free asset, forms a market orientated measure of the country’s macroeconomic health, which has direct implications for the credibility of the country, the sustainability of its debt, and its capability for more borrowing. It can be regarded as a forward-looking indicator of the probability of default.

The determinants of government bond yield spreads deserve our attention because they are relevant for international financial markets, economic agents and governments. Indeed, they are important for three reasons. First, they are a key determinant of the interest rates a country faces in the international financial market and therefore of its borrowing costs. Second, the government bond yield spread may have a constraining impact on the ratings assigned to domestic banks or companies. Third, there exist institutional investors who prefer to have lower bounds for the risk in their investments, and they will choose their bond portfolio composition taking into account the country risk perceived via the government bond spreads. Furthermore, they are very important for government policy since they influence the credit ratings of each country which has various implications for the lending strategy of the country. For instance, when conducting open market operations, the European Central Bank can only take as collateral bonds those that have at least a single A attributed by at least one of the major rating agencies. Of course, this was the case until recently, since the temporary program of quantitative easing of 2015 allows the acceptance even of junk bonds as collateral for future lending.

In terms of country risk, the government bond yield spread represents the risk premium paid by governments relative to the benchmark government bond. The empirical literature has explored a large set of explanatory variables to explain the variability of sovereign spreads. From a theoretical perspective, although sovereign debt is notably different from corporate debt, these instruments can be priced in a similar manner. Many authors have emphasized the role of country-specific economic factors in explaining variation in credit risk spreads. In the present study, the set of the determinants reflects the country's macroeconomic health.

The history of country risk analysis goes back to late 1960s when Avramovic et al. (1964) examined the factors that affect the country's balance of payments and its ability to service debt. He suggested a combination of long term and short term indicators for evaluating the country's debt servicing capacity. He considered the following short-term indicators which are related to liquidity aspects of a country's ability to service its debt: (1) growth rate of export volume, (2) the ratio of debt service payments to exports, and (3) the ratio of foreign exchange reserves to imports. The long-term indicators were considered mainly to determine the conditions under which economic growth financed in part by foreign capital can succeed, and include the following variables: (1) growth rate of GDP, (2) the ratio of investment to GDP, (3) the ratio of exports to GDP, and (4) the rate of inflation.

Frank and Cline (1971) investigated the quantitative importance of indicators in determining default probability using discriminant analysis to identify each observation as belonging to one of two possible populations: default or non-default. Their results indicate that the debt-service ratio, the debt amortization ratio, and the ratio of imports to reserves are important determinants of the debt servicing capacity.

Sachs, et al. (1983,1985) investigated the role of various macroeconomic policies and fundamentals for the debt crisis and provided the empirical rationale for using certain economic fundamentals in the determination of the risk-premium in international capital markets. They emphasized the importance of trade and exchange rate policy for the performance of a developing country. McDonald (1982) provided an exhaustive survey of the subject for that period.

In a seminal paper, Edwards (1984) analyzed the theoretical determinants that affect the default country risk. He links the probability of default with a set of macroeconomic variables and shows that debt and debt service are the key determinants, followed by the current account balance, international reserves, and the country's investment ratio. Min (1998) suggested a larger set of macroeconomic variables, including the domestic inflation rate, net foreign assets, terms of trade, and the real exchange rate. Rowland and Torres (2004) used panel data from 16 emerging market issuers to identify the determinants of the spread and of the creditworthiness. They showed that credit worthiness is also a key for emerging market sovereign debt cost, while credit ratings indicators are, found to be influenced by macroeconomic fundamentals.

Edwards (1986), compared the pricing of bond and bank loans to test whether the markets are significantly different. He showed that bond data confirm some of the most important implications of borrowing models, i.e. using yields on less developed countries he found a positive effect of higher debt ratios on the risk premium. Furthermore, influential papers in the area include Haque (1996), Eaton, Gersovitz, and Stiglitz (1986), Eichengreen and Portes (1989), and of course Cantor and Packer (1996). The more recent literature includes the work of Afonso (2003), Bissoondoyal-Bheenick, E. (2005), Afonso, et al. (2007), Baldacci et al. (2008),Attinasi, et al. (2009), Acharya and Steffen (2013), Acharya, et al. (2016).

The analysis would be incomplete if there was no discussion of the credit rating industry. The leading credit agencies of the world are the Moody's Investor Service, Standard and Poor's, and Fitch Ratings. They constitute an important factor of global finance, and their risk assessments have great impact on the international lending system and governments' borrowing policies. In particular, sovereign ratings are gaining importance as more governments with greater default risk borrow and their bonds are traded in international bond markets. Sovereign ratings are important not only because some of the largest issuers in the international capital markets are national governments, but also because these ratings affect the ratings of private borrowers of the same nationality.

But while the ratings have proved useful to governments seeking access to markets, the difficulty of assessing sovereign risk has led to agency disagreements and public controversy over specific ratings. Recognizing this difficulty, the financial markets have shown some skepticism toward sovereign ratings, mainly because of the ambiguous methods used by these agencies to rate economic entities. In their statements on rating criteria, the major agencies list numerous economic, social, and political factors that underlie their sovereign credit ratings. Identifying the relationship between their criteria and actual ratings is difficult, however, partly because some criteria are not quantifiable. According to Cantor and Packer (1996), the agencies provide little guidance about the relative weights assigned to each factor.

2.4 The determinants of government bond yield spreads

A baseline specification that links the spread with a set of macroeconomic variables is presented in Baldacci, et al. (2008), among others. Consider the equation

$$y_{it} = a_i + \beta\, x_{it} + u_{it}, \quad i = 1,\ldots,N, \quad t = 1,\ldots,T,$$

where y_{it} is the logarithm of the bond spread for country i and year t, i = 1, ..., N, t = 1, ..., T, x_{it} is a vector of explanatory variables, u_{it} is the error term and β is a vector of coefficients. In what follows in this section, I review the various definitions of the vector *x* that are available in the literature.

Min (1998) selected 18 explanatory variables and classified them into the following groups: (i) liquidity and solvency variables, (ii) macroeconomic fundamentals, (iii) external shocks, and (iv) dummy variables. Baldacci, et al. (2008) proposed the categories "solvency and liquidity, "global financial conditions," and fiscal vulnerability. Afonso, et al. (2007) divided the variables in *x* into four main blocks: (i) macroeconomic performance (per capita GDP, unemployment rate, inflation rate, real GDP growth), (ii) government performance block (government debt, fiscal balance, government effectiveness), (iii) external balance (debt, foreign reserves, and current account balance), and (iv) other explanatory variables (default history, European Union, and regional dummies).

The rating agencies assess the risk of default by analyzing a wide range of factors, e.g., solvency factors, which affect the capacity to repay the debt, and socio-political factors, which might affect the willingness of the borrower to pay. For instance, S&P assesses the rating by measuring the country's performance in each of the following areas: political risk, income and economic structure, economic growth and prospects, fiscal flexibility, general government debt burden, off-shore and contingent liabilities, monetary flexibility, external liquidity, and public- and private-sector debt burden.

Building on the literature and in particular on Edwards (1984), Cantor and Packer (1996), Afonso, et al. (2007), Baldacci, et al. (2008), I list the main macroeconomic and qualitative variables as well as their influence on the spread, as described in previous models.

First, real per capita GDP and its growth rate, which have a positive impact on a country's overall rating, and thus a negative impact on the spread. The greater the tax base of the borrowing country, the greater its ability to repay the debt. In addition, the rating agencies appear to assume a threshold effect in the relationship between economic development and risk, in that once a country reaches a certain level of income it may be less likely to default. These variables can also serve as proxies for political stability, since more developed economies (with high GDP per capita) are expected to have more stable institutions, which prevent government over-borrowing.

Second, the inflation rate, whose impact on the spread is uncertain. On the one hand, inflation reduces the real stock of outstanding government debt in domestic currency, leaving overall more resources for servicing the government debt. As far as this effect is concerned, inflation can cause the spread to fall. On the other hand, inflation is a macroeconomic problem with serious consequences. When caused by the monetization of the budget deficit, it points to structural problems in the government's finances. When a government appears unable or unwilling to pay for current budgetary expenses through taxes or debt issuance and resorts to inflationary finance, this may be bad news for its creditors. Also, public dissatisfaction with inflation may lead to political instability, thus causing the spread to rise. Min (1998) claims that the inflation rate can be regarded as a proxy for the quality of economic management, so higher inflation can actually lower the yield spread. The empirical findings of the present study, however, support the view that inflation causes the spread to rise. This result is in accordance with Edwards (1984) and McDonald (1982), who argue that higher inflation raises the probability of a balance of payments crisis as well as the probability of default on the debt, thus causing the spread to rise.

Third, the rate of unemployment: the higher this rate is the lower the overall rating of a country and the higher the spread will be. A country with lower unemployment rate tends to have a flexible labor market, which is less vulnerable to changes in the economic environment. In addition, lower unemployment reduces the fiscal burden of unemployment and the social-security benefits, while broadening the tax base. Note that only a few studies incorporate this variable in their analysis.

Fourth, the government debt-to-GDP ratio: the higher this ratio is, the more difficult it becomes to service the debt, especially when it is denominated in foreign currency, i.e., the higher is the risk of default, and hence the higher the spread will be. The rise in the economy's indebtedness leads to an additional fiscal burden, either directly due to a sell-off of foreign government debt or indirectly due to the need to support over-indebted domestic borrowers.

Fifth, the budget deficit, which erodes country's creditworthiness and raises the spread. A large budget deficit absorbs private domestic saving and suggests that the government lacks the ability or will to tax its citizens to cover current expenses and to service its debt. Persistent deficits may signal a low quality of institutions, thus eroding creditworthiness.

Sixth, Real GDP growth rate– positive impact: higher real growth strengthens the government's ability to repay outstanding obligations, and exhibits macroeconomic health.

Seventh, the current-account deficit, which also erodes creditworthiness and raises the spread. For a large current-account deficit indicates that the public and private sectors rely heavily on funds from abroad. Persistent current-account deficits result in high indebtedness, which may become unsustainable.

Eighth, quality-of-institutions variables, that is, government effectiveness, voice and accountability, political stability, regulatory quality, rule of law, and control of corruption. They are all assumed to have a positive impact on the credibility of the government, thus lowering the spread. High quality of public services, competiveness, and low level of bureaucracy are factors that should affect positively the ability of the government to service its debt. Afonso et al (2007) used all the World Bank's Governance Indicators: voice and accountability, political stability, regulatory quality, rule of law, control of corruption and government effectiveness, and he found that only this one turned up as significant.

Ninth, default history, which has a negative impact on a country's creditworthiness, thus leading to a higher spread. Other things equal, a country that has defaulted on its debt in the recent past is widely perceived as a high credit risk (Cantor and Packer 1996). Both theoretical considerations of the role of reputation in sovereign debt (Eaton 1996) and related empirical evidence indicate that defaulting countries suffer a severe decline in their standing with creditors (Ozler 1991). Past sovereign defaults may indicate moral hazards and attempts to reduce the outstanding debt burden via a default.

Tenth, external shocks to the economy, which can influence the spread in either direction. Barr and Pesaran (1997), among others, suggest that changes in international interest rates have been a key factor influencing capital flows to developing countries in the 1990s. In addition, higher global interest rates may affect not only the cost of new borrowing, but also the interest charges on existing debt which has been contracted at a variable interest rate.

Eleventh, loan duration, whose effect on the spread is also ambiguous (Feder and Ross, 1982). This variable measures the (weighted) average maturity of loans granted to a particular country.

Twelfth, loan volume, whose effect on the spread is also uncertain. This variable shows the average value of each loan, and can be obtained from market data such as the World Banks' edition (Borrowing in International Capital Markets).

Thirteenth, propensity to invest, the ratio of gross domestic investment to GDP, which captures the country's prospective for growth (Edwards 1984).

Fourteenth, public investment, which is expected to influence the spread negatively, as a sounder fiscal stance and an improved composition of public spending lower default probability (Akitoby and Stratman, 2006).

Needless to say, other variables may also affect the spread applied to a country, e.g., political risk, geographical risk, corruption or other social indices. The present study includes such variables, although it focuses on macroeconomic factors, which, to a certain extent, reflect the above variables.[4]

Speculation also affects government bond spreads. An overestimated or underestimated spread reflects a counterfeit probability of default, which is not accordance with the government's observed macroeconomic performance. I argue that this difference forms the root cause for the existence of the threshold in the spread determination.

The composition of the set of the spread determinants is important. I argue that a small number of macroeconomic and institutional fundamentals in the spread function is sufficient. This view is supported by many authors in the literature. Cantor and Packer (1996) concluded that the risk ratings can be largely explained by a small set of variables, namely, per capita income or level of economic development, GDP

[4]In the original version of the thesis, I considered only pure macroeconomic variables as determinants of the spread. During the thesis defense, Professor Antzoulatos expressed considerations related to the omitted variables problem. Although the diagnostic tests I have conducted did not indicate any evidence of misspecification, in response to this criticism, I have incorporated quality-of-institutions variables. As it will be presented in Chapter 4, their input did not change the results significantly.

growth, inflation, debt, and default history. Afonso (2007) found that six core variables have a consistent impact on sovereign rating and thus on government bond spread pricing, namely GDP per capita, real GDP growth, government debt, government effectiveness, debt, external reserves, sovereign default indicators, and membership of the European Union. He also highlighted that the government related variables have a stronger effect than that reported in the existing literature. Monfort (2011) and Favero, et al. (2010) suggested that a model with a limited number of variables may be able to explain the bulk of euro-area yield-differential fluctuations.

In order to visualize the analysis conducted above, in Table 2.4, I present the explanatory variables, their expected sign and the studies that they have been used. In my survey I decided to form the set of the determinants of the spread function focusing mainly on pure macroeconomic variables, namely the inflation rate, the debt to GDP ratio, the real GDP growth rate, the primary surplus, the unemployment rate, plus a risk free interest rate to incorporate for shocks in Global Economy. For the sake of completeness, I have added some quality-of-institutions variables to estimate their effect on the spread. To my point of view the synthesis of the subset is intuitive, clear and sufficient to model government bond spread dynamics. From the survey of the literature that I have presented, I claim that this specific subset of indicators has not been used in the literature so far.

It is essential to mention that, for the selection of the explanatory variables, I adopted the so called “American approach,” or “from specific to general”, which starts from a model that is thought to be adequate, and builds on it by adding more explanatory variables until a battery of diagnostic tests, such as the RESET, the Durbin-Watson test, and the Durbin-Wu-Hausman test (for the consistency of the least-squares estimators), fail to indicate evidence of misspecification.

I present analytically the most highlighted models used and the selection of the corresponding variables in the Appendix A.1. It is obvious that the set of explanatory variables that I have chosen to conduct my analysis is not present in the related literature. For the sake of complicity, in AppendixA.2 I present also a useful Table from Cantor and Packer (1996) that links the estimated coefficient of the variables with the class of the ratings.

Table 2.4 List of explanatory variables, expected sign and previous studies

VARIABLE	EXPECTED SIGN	PREVIOUS STUDIES	NOTES
Real per capita GDP and its growth rate	-	Edwards (1984), Cantor & Packer (1996), Monfort and Mulder(2000), Eliasson (2002), Afonso (2003), Afonso et al (2007), Alexe et al. (2003), Canuto, Santos and Porto (2004), Borio and Packer (2004), Bissoondoyal-Bheenick (2005) - S&P (2004, 2006), Fitch (2006) and Moody's (2006)	Proxy for political stability
Inflation rate	+	Edwards (1984), Cantor & Packer (1996), MonfortandMulder(2000), Eliasson (2002), Hu, Kiesel and Perraudin (2002), Afonso (2003), Afonso et al (2007), Alexe et al. (2003), Canuto, Santos and Porto (2004), Borio and Packer (2004), Bissoondoyal-Bheenick, Brooks and Yip (2005), Bissoondoyal-Bheenick (2005), Butler and Fauver(2006) - S&P (2004, 2006), Fitch (2006) and Moody's (2006)	Uncertain sign in the bibliography - public dissatisfaction with inflation may lead to political instability,
Rate of unemployment	+	Bissoondoyal-Bheenick (2005) - S&P (2004, 2006) and Moody's (2006)	
Government debt-to-GDP ratio	+	Edwards (1984), Monfort and Mulder (2000), Hu,Kiesel,and,Perraudin(2002)* (as debt to GNP) Alexe et al. (2003), Borio and Packer (2004), Bissoondoyal-Bheenick (2005), Butler and Fauver (2006), Afonso et al (2007), S&P (2004, 2006) and Moody's (2006)	
Budget deficit (government budget surplus/total surplus)	-	Cantor & Packer (1996), Monfort and Mulder (2000), Eliasson (2002), Afonso (2003), Afonso et al (2007), Alexe et al. (2003), Canuto, Santos and Porto (2004), Bissoondoyal-Bheenick (2005) - S&P (2004, 2006), Fitch (2006) and Moody's (2006).	Persistent deficits may signal a low quality of institutions
GDP growth rate	-	Cantor & Packer (1996), Monfort and Mulder (2000), Eliasson (2002), Hu, Kiesel and	

		Perraudin (2002), Afonso (2003), Afonso et al (2007), Canuto, Santos and Porto (2004), Borio and Packer (2004) - S&P (2004, 2006), Fitch (2006) and Moody's (2006)	
Current-account deficit	+	Edwards (1984)*(as ratio to GDP), Cantor & Packer (1996), Monfort and Mulder (2000), Afonso (2003), Afonso et al (2007), Alexe et al. (2003), Bissoondoyal-Bheenick, Brooks and Yip (2005)*(as ratio to GDP), Bissoondoyal-Bheenick (2005))*(as ratio to GDP), S&P (2004, 2006), Fitch (2006) and Moody's (2006)	
Default history	+	Cantor & Packer (1996), Hu, Kiesel and Perraudin (2002)* (in previous year,) Afonso (2003), Afonso et al (2007), Borio and Packer (2004)* (years since default), Canuto, Santos and Porto (2004)- S&P (2004, 2006), Fitch (2006) and Moody's (2006)	
External shocks to the economy	?	Edwards (1984), Barr and Pesaran (1997)	
Loan duration	?	Federand Ross (1982), Edwards (1984)	
Loan volume	?	Edwards (1984)	
Propensity to invest	-	Edwards (1984,1985)	
Public investment (Gross fixed capital formation at current prices: public sector)	-	Edwards (1984,1985)	
Dummy variables	?	Edwards (1984), Cantor & Packer (1996),Monfort and Mulder(2000), Hu, Kiesel and Perraudin (2002) –Institutiona lInvestor, S&P (2004, 2006), Fitch (2006) and Moody's (2006)	Member of EU or not, regional dummies, nonindustrial countries dummy, legal origin dummies and others
Quality-of-Institutions variables (government effectiveness, voice and accountability, political stability, regulatory quality, rule of law and control of corruption)	-	Alexe et al. (2003), Afonso et al (2007) - S&P (2004, 2006)	

2.5 The selection of the benchmark and the risk free rate

The notion of the risk-free asset, which is usually regarded as the return on an ideal, perfectly liquid asset carrying no credit risk, plays an important role in financial markets and monetary policy analysis. Risk-free rates most notably serve as a key benchmark for pricing risky assets. In particular, a risk-free rate can be used as a discount rate to calculate the present value of investment projects or the value of future financial payments. Risk-free yields are also important for monetary policy-makers both because the pass-through of policy rates across the risk-free term structure is a key part of the monetary policy transmission mechanism and because risk-free interest rates can provide information about market expectations of key economic variables, including the evolution of the key ECB interest rates.

The theoretical notion of the risk-free rate is typically measured by the yield on high-rated sovereign bonds or interbank interest rates. Using this measure, over the last three to four decades there has been a trend decline in risk-free yields across major developed economies, and long-term yields have reached historically low levels over the last couple of years ECB Bulletin (2014).

In many studies, the selection of the risk-free rate was made in a trivial manner, and in most cases it varied depending on the period and the priced asset. A crucial question for this study is, which risk-free asset is the most appropriate to choose? I have made an attempt to answer this question, first because the risk-free rate is assumed to capture external global shocks, and second because, when valuing government bond spreads, a bad choice of a proxy for the risk-free rate might lead to over- or under-pricing biases.

Edwards (1984), among other authors and financial institutions, uses the Libor rate as a proxy for the risk-free rate in the spread function. Cantor and Packer (1996) and major central banks underline the role of AAA- assessed sovereign bonds as risk-free assets. Depending on which side of the Atlantic Ocean one lives, the 10-year German bond and the 10-year Treasury Bill are the most widely used in the literature and in major financial markets; see, for instance, Bloomberg, Reuters, and elsewhere. Banks use the Euribor and the Libor and some complicated measures, such as the overnight indexed swap (OIS); see Hull and White (2013). Before the financial crisis it was common among market participants to use interest rate swaps as benchmark risk-free rates, in which the variable rate was based on Euribor rates. However, in the presence of increased credit risk priced into Euribor rates, the yield curve based on Euribor linked swaps was clearly no longer a good proxy for the risk-free yield curve; see ECB Bulletin (2014).

Against this background, I introduce the MINRFB variable, which is defined as the minimum risk-free benchmark for each year, among the German, the Libor over Euro, and the 10-year Treasury Bill rate. Intuitively, the benchmark is considered as “the” risk free asset, so by choosing the minimum of the three widely used ones, I create “the most” risk-free benchmark. To my knowledge, such a proxy has not been used in the literature. As was mentioned in section 1.1, there was some criticism for the use of this definition. In particular, Professor Antzoulatos argued that this definition suffered from the following two problems: (i) the currency is different, since the 10-Treasury is in dollars, whereas the other two benchmarks are in Euros; (ii) the maturity horizon is different. As suggested by Favero et al. (1997), the first problem can be solved by directly correcting the spreads for exchange rate risk. As for the second problem, the descriptive analysis showed high correlation among these variables, despite the fact that their maturity is different. In future work, it might be worth investigating if the maturity horizon affects the selection of the benchmark variable or not.

Table 2.5.1 Correlation matrix of the main benchmarks

	Libor over Euro	10-year Treasury	German	MINRFB
Libor over Euro	1			
10- year Treasury	0.817	1		
German	0.756	0.909	1	
MINRFB	0.959	0.909	0.847	1

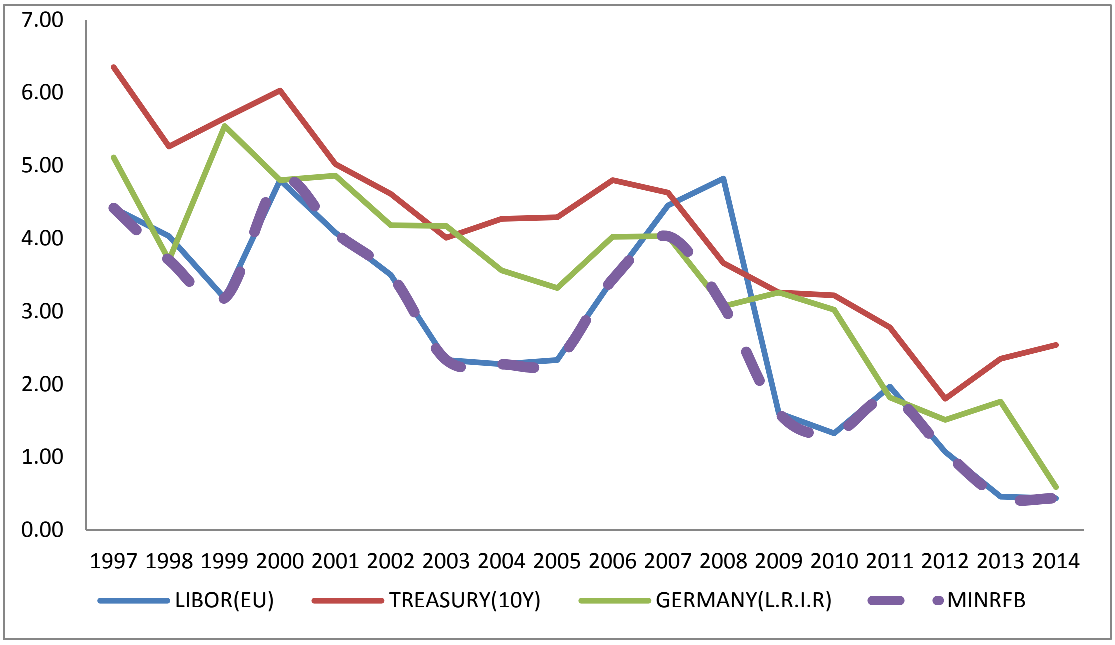
All the variables are found to be stationary. From the correlation table above is obvious that the selected benchmark variables are highly correlated. The 10-year Treasury although it is dollars, is highly correlated with Germany‘s long run interest rate (0.909) and the Libor over Euro (0.817). Thus, despite the fact that the variables differ in terms of currency and maturity, the correlation analysis indicates that their evolution over time resembles one another. Furthermore they are all highly correlated with the MINRFB variable.

Table 2.5.2 Descriptive analysis of the main benchmarks

	Libor over Euro	10- year Treasury	German	MINRFB
Mean	2.806	4.141	3.462	2.659
Standard error	0.346	0.306	0.316	0.317
Median	2.757	4.280	3.630	2.701
Mode	2.332	NA	NA	2.332
Standard deviation	1.469	1.298	1.341	1.344
Sample Variance	2.159	1.686	1.797	1.805
Kurtosis	-1.267	-0.784	-0.186	-1.049
Skewness	-0.172	-0.096	-0.576	-0.188
Range	4.388	4.550	4.950	4.365
Minimum	0.434	1.800	0.590	0.434
Maximum	4.822	6.350	5.540	4.799
Sum	50.515	74.530	62.320	47.863

To visualize which one of the above rates, is the most risk free, I present figure 1.

Figure1: Evolution of the major benchmarks



In the Chart 1, I present the evolution of the major benchmark assets, i.e., the Libor over Euro, the 10-year Treasury Bill, The German Long Run Interest Rate, provided by the ECB, and the variable MINRFB, which I have introduced for the period 1997-2014. It is obvious that it is the least risky benchmark for the specific period of time. In most of the cases it was the Libor over Euro, except from the period 2006-2009, where the German bond appeared the most secure. The 10-year Treasury Bill appeared the most risky, although its evolution resembles the German bond. MINRFB solves the problem of benchmark variations through time and provides a reliable proxy for the risk-free rate in the spread function. It is worth mentioning that MINRFB took 15 times values form the Libor over Euro, three times from the German and none from the 10-year Treasury. Thus it took values from the same currency over the whole sample.

In the analysis presented in Chapter 4, I use only the Libor over Euro as the benchmark variable.

2.6 Threshold and switching models

Intuitively, the notion of regimes is closely related to the familiar concept of good and bad states, or states with low and high risk, or winning and losing. Many economic variables or relationships exhibit breaks in their behavior, because of important events, such as financial crises and sudden changes in government policy; see Jeanne and Masson (2000), and Hamilton (1988, 2005). Of particular interest is the tendency of many economic variables to behave quite differently during economic downturns, when the factors of production are underutilized, from their long-run tendency to grow, which governs economic dynamics, see Hamilton (1989). Abrupt changes are an interesting feature of financial and macroeconomic data, and their effect in pricing assets is an important issue.

A regime switching model allows the behavior of the variable of interest to depend on the state of the system. Despite the intuitive appeal of multiple-regime modeling, the mathematical framework for and the extensions to panel data, has only been developed the past twenty years. An interesting question that has given force towards this direction has been stated in Hansen (1997). Are regression functions stable across the whole sample period, or do they fall into discrete classes? This question may be addressed using threshold regression techniques. Threshold models divide individual observations into different classes, depending on whether they exceed some threshold or are below it.

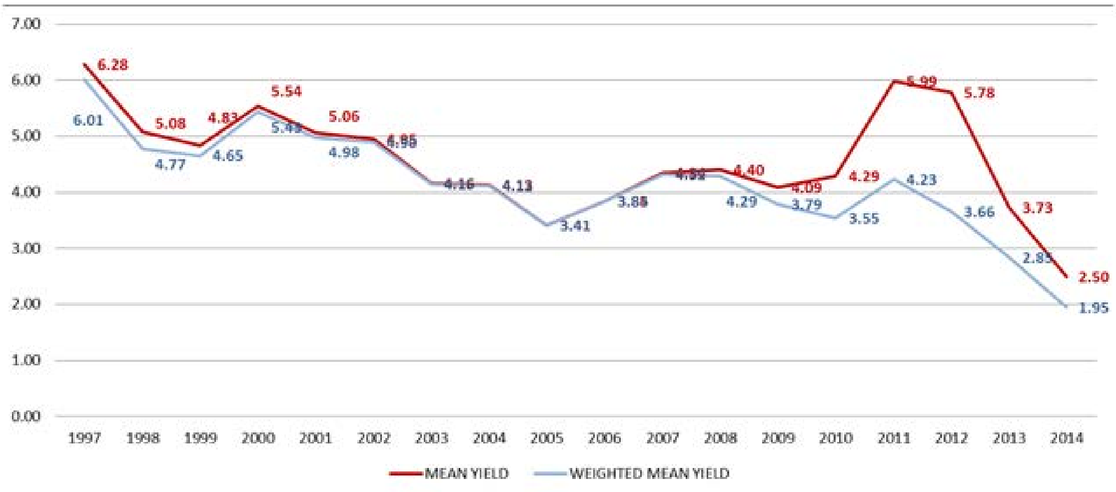
As Hansen (2000) notes, threshold models have a wide range of applications in economics. Direct applications include models of separating and multiple equilibria. Others include empirical sample splitting of a continuous variable, such as firm size. In addition, threshold models may be used as a technique for nonparametric estimation. For example, a popular application in the nonlinear time series literature is the threshold autoregressive model (TAR). Threshold models appear often, as special cases of more complex statistical problems, such as mixture models, switching models, Markov switching models, and smooth transition threshold models.

Regime switching models have been introduced by Hamilton (1988, 1989, 1990, 1994, 1996) and have become popular in financial modeling. In these models, the switch between regimes is regulated by an unobserved Markov chain. The presence of the unobserved Markov chain makes estimation of the model more difficult. The original application of regime switching was Hamilton's (1989) seminal work on business-cycle recessions and expansions, where the regimes captured cycles of economic activity around a long-term trend. He provided a nonlinear filter which draws inferences about the Markov chain and produces the conditional likelihood of the model for ML estimation of the parameters.

The selection of the appropriate threshold is an important issue. The literature presents various options. Applications to financial series identify regimes that correspond to different periods in regulation, policy, and other secular changes. Regimes identified in interest rates correspond to policy making depending on the incumbency of different Federal Reserve Chairs (see, for example, Sims and Zha, 2006). In equities, different regimes correspond to periods of high and low volatility, and long bull and bear market periods Pagan and Sossounov, 2003). Also regimes are defined depending on the level of global risk aversion, proxied by specific indexes such as the CBOE Volatility Index (VIX), which can be regarded as a measure of international risk aversion, because it is often considered by many to be the world's premier barometer of investor sentiment and market volatility. As far as spread determination is concerned, a regime-switch has been documented by many studies, especially for the Euro-area peripheral sovereigns during the crisis; see Aizenman, et al. (2011), Gerlach, et al. (2010), Montfort and Renne (2012), Favero and Missale (2011).Two different regimes have been described, a crisis and a non-crisis regime, with additional fundamental factors important in the crisis regime. In addition, one of the most important variables discussed is the level of the debt-to-GDP ratio and its relation to the economy's capacity to grow. For instance, using descriptive analysis, Reinhart and Rogoff (2010) claim that a debt-to-GDP ratio over a threshold of 90%, GDP growth decelerates.

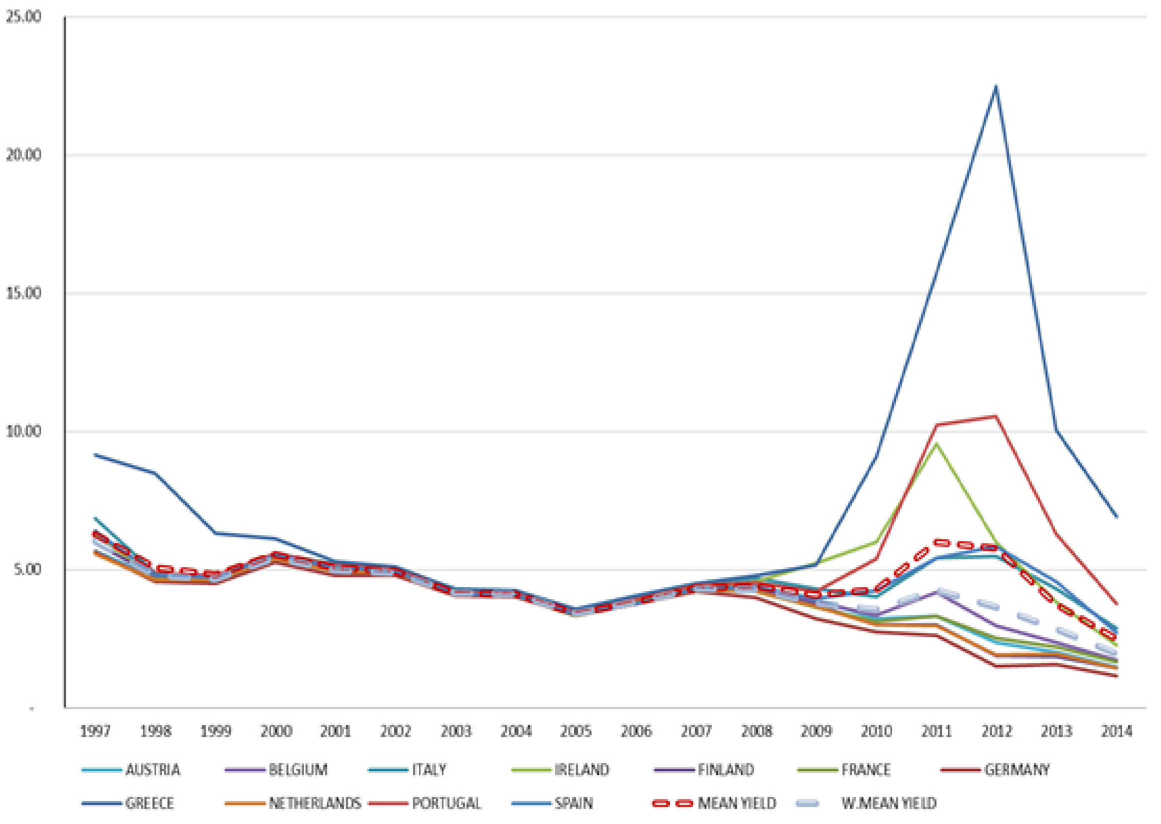
The only thing that appears to be common in the literature is that what matters is the state of the economy, according to which threshold is selected. Originally, in the present study, I provided a market orientated threshold variable, namely the mean spread (yield) and the weighted mean spread for each year of the time period 1996-2014 for 11 Eurozone countries, namely Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Spain, Portugal and the Netherlands. This data set can be found in various papers; see, e.g., Barrios, et al. (2009). In figure 2, I present the evolutions of these two over time.

Figure 2: Mean yield vs weighted mean yield



From the above figure we can notice that the curves of the mean yield and the weighted mean yield are very close, until 2009 that the crisis begun. In figure 3, I present the government bond yields over the specific time period and I compare them with the mean and the weighted mean rate. The results are similar.

Figure 3: EU 10-year Government bond yields vs mean yields



In order to use a measure that is transparent, credible, and independent from the lenders' and the borrowers' point of view I have constructed a rating based threshold based on the credit ratings of the associated countries. More specifically, I sort the countries depending on their credit rating, provided by Moody's, and divide them into classes. As the "fair" value I take the average spread of the associated rating class that each country belongs to each year, thus taking country ratings into account.[5]

[5] In the original version of the thesis, for each year, I used the mean spread from the 11 Eurozone countries as the "fair" value of the spread.

Ideally, a policy maker would accept the maximum for his/her country based on its macroeconomic performance, but if this is not achievable, he/she might at least accept the feasible, which can be regarded as the mean yield rate of the associated rating class. In my view, he/she might change his/her decision to borrow or not depending on the state of the economy, i.e., below or above the mean yield rate of the rating class that the country belongs to. In the present study, it is crucial to determine whether the proposed threshold creates any asymmetries and to what extent regarding the impact of the selected explanatory variables on the spread. To my knowledge, all the thresholds proposed here has not been used in the literature, which uses two approaches to determine the value of the threshold: (1) a purely ad-hoc way, and (2) endogenously from the data; see, for instance, Hansen (1996, 2000).

For the sake of completeness, I present in Table 2.6 an analysis of the performance of the 11 Eurozone countries under the various definitions of the threshold. In Appendix A.3, I present the full matrices with the performance of every country, each year under the different selection of the threshold, taking the value one if the spread is above the threshold and zero if it is below. Interestingly, using the average spread of the EU countries, some countries were always lying in the low spread area, whereas using the rating based threshold, the performance is just the opposite. For example, Austria and France, which belong to the Aaa rating class for the whole time period, when the average threshold is applied they appear 4 and 0 times, respectively, above the threshold, whereas under the rating based threshold they appear above it 17 and 10 times, respectively. The set of countries that are above or below the threshold value differs from year to year, as it can be seen from Appendix A.3. However, some countries such as Greece, Italy, Portugal, Spain, and Ireland formed most of the time the set of countries above the threshold.

Table 2.6 Country's performance index per threshold

	RATING BASED	MEAN	WEIGHTED MEAN
AUSTRIA	17	4	8
BELGIUM	6	2	6
ITALY	15	13	18
IRELAND	14	7	13
FINLAND	12	1	5
FRANCE	10	0	0
GERMANY	0	0	0
GREECE	17	18	18
NETHERLANDS	5	0	0
PORTUGAL	9	16	18
SPAIN	12	6	13
AVERAGE ABOVE	6.50	3.72	5.50
AVERAGE BELOW	4.28	7.28	5.50

Notes: The figures reported in this table indicate the number of times that a country is in the high spread regime (dummy equals one).

2.7 Estimation methods

I now review the main econometric approaches to the modeling of sovereign spreads, i.e., the specification of the functional form and the estimation methodology. There are two major paths of empirical work in the literature: (1) the application of the Ordinary Least Squares (OLS) or Generalized Least Squares (GLS) to panel data, assuming fixed or random country-specific or time effects; and (2) ordered response models. The first uses linear regression methods on spread or credit-rating equations. Cantor and Packer (1996) applied linear OLS regressions to the ratings using a cross section of 45 countries. Afonso (2003), Alexe, et al. (2003), and Butler and Fauver (2006) use the same methodology. Straightforward generalizations to panel data, assuming fixed or random effects, include Monfort and Mulder (2000),Eliasson (2002), and Canuto, et al. (2004).

The other strand of the literature uses ordered response models, which apply mainly to the risk rating industry. Since the ratings area qualitative ordinal measure, the use of ordered probit estimation might seem more appropriate; see Bissoondoyal-

Bheenick (2005). On the other hand, the ordered probit asymptotic properties do not apply to a small sample, as is the case with the determinants of the ratings using a cross-section of countries. It is therefore desirable to use panel data, but when doing so, one has to be careful, since the use of panel data to estimate an ordered probit model is not straightforward, because of the presence of country-specific effects.

While in most studies the model for the spread is assumed to be linear, there exists an increasing trend in the literature suggesting that the pricing process of assets, including sovereign debt, may be nonlinear. In the present study, I follow the OLS or GLS approach. The basic question that I would like to answer is, which specification is the most appropriate, the linear or the nonlinear? A good discussion of this topic can be found in Enders (2014, pp. 407-410). He mentions that it would be disastrous for NASA to use a flat map of the earth to plan the trajectory of a rocket launch.

There is an extensive theoretical research suggesting that the pricing of assets, including sovereign debt, may be nonlinear. Recent work stresses the importance of nonlinear effects and amplification dynamics through the price mechanism during financial crises (Brunnermeier and Oehmeke, 2009). Previous empirical work has identified non-linearity in the spread determination model for euro-area peripheral sovereigns during the crisis; see Aizenman, et al. (2011), Gerlach, et al. (2010), Montfort and Renne (2012), Borgy, et al. (2011), and Favero and Missale (2011).

The remarkable work of John Maynard Keynes, Daniel Kahneman, Amos Tversky, and Robert Shiller (Keynes 1936, Kahneman and Tversky 1979, Shiller 1993, 2005), among others, has indicated that asymmetry is fundamental to the human condition, and nonlinearity is present in global markets behavioral economics. For the sake of completeness, I will use both linear and nonlinear models for the spread and see how they perform.

CHAPTER 3: THE MODEL

3.1 Introduction

Imagine the incumbent politician or policy maker who wants to finance his/her government program by borrowing from the markets while the markets price his/her country, based on its macroeconomic conditions. He/She is fully informed about the country's financial situation so he/she has an idea, based on the international financial system and the sovereign bond market, about the interest rate he/she might be priced. He/She believes that the country's financial condition is sufficient for a government loan of an amount, say K, with an interest rate not more than 6%, which is the mean market rate of the 10-year government bond yields. As in Section 1.1, I assume that there exists a fair spread for this loan that both parties are aware of. Again, a crucial question is, What would be his/her response if the bank offers him/her an interest rate that is (i) higher than the subjective "fair" rate of 6%, a state of affairs which we call high-spread regime, or (ii) lower than or equal to the "fair" rate, a state we call low-spread regime?

Again, as in Section 1.1, I assume that our policy maker derives utility from the assessed spread, and might be a risk seeking individual. The crucial question that I ask in this study is, Are there any asymmetries reflected in the determinants of the assessed spread, and if yes, to what extent do they affect the decision making process?

In sum, the model I propose can be described as follows. In accordance with my arguments exposed in Chapter 1, there exists, a reference point, the fair price of the spread rate, on which people base their decisions. The policy maker's sub-utility function, depends only on the assessed spread, which in turn depends on macroeconomic variables that he/she can influence. I assume risk seeking behavior based on the context of gaining or loosing relative to a reference point. To my knowledge, this formulation is not present in the literature. The government bond spread has become the leading variable in the recent financial crisis and affects the countries' macroeconomic policy and consequently social welfare. I propose a new set of variables that influence the spread and are influenced by the policy maker. I argue, on both theoretical and empirical grounds, that there exists a reference point in the decision making process. On a theoretical level, the reference point plays a role if we attempt to solve the utility maximization problem. On an empirical level, I test for asymmetries in the effects of the determinants of the spread function, where the reference point serves as a threshold. If asymmetric effects are present, I will take them to mean that the decision making process has at least two states, thus supporting my argument that there exists at least one reference point, implying that it does matter in which state the economy operates.

3.2 The importance of the spread and the decomposition of the risk premium

The recent financial crisis, which started in the USA in 2007 with the collapse of many well-known financial institutions, and the subsequent fear of a contagion phenomenon due to debt servicing capacity problems in the Euro area, has generated great concern among the economists, bankers and politicians. The potential effect of public debt and other variables on government bond yields is an important issue for economists and policy makers. Increasing indebtedness or macroeconomic instability may cause bond yields to go up, thus raising the cost of borrowing and imposing disciplinary programs on governments. Debt servicing is a complex and challenging task for decision makers and an important issue in designing effective macroeconomic policy. In particular, the ability of financial institutions, banks and governments to derive routines that distinguish the various levels of risk and to construct models that incorporate all the factors affecting country risk, is of great importance in a globalized economy, where consumers, companies, governments and financial institutions are all tied up following the same rules of engagement in financial transactions.

The purpose of this study is to construct a model that incorporates various elements of country-risk assessment and study its implications for macroeconomic policy. Central role in the analysis plays the determination of the interest rate and thus the spread that the capital markets offer to governments that want to borrow in order to service their debt or to finance expenditures and investment policies in their countries. I consider the offered yield as a measure of risk, which reflects how "healthy" the country's macroeconomic condition is. In this sense, "healthier" countries are granted with a lower interest rate and less "healthy" countries are charged with higher interest rates when borrowing from international markets, as a penalty for the presence of various types of risk. There is an equilibrium relationship between the interest rate and the probability that a country will default, such that higher probability of default implies higher interest rate due to higher risk exposure. The probability of default is linked to macroeconomic and quality of institution variables and both parties (lenders and borrowers) are greatly concerned with the nature of this link.

In this study, I decompose the market interest rate (r) into two parts, the interest rate margin, also referred to as the spread, denoted as (s), and the risk-free rate, denoted as (r^*). The spread is a fixed rate of interest in addition to the risk-free rate, which reflects the perception of risk for each country and the lenders' profit margin, based on the country's macroeconomic condition. The risk-free rate is usually the Libor over Euro or the Euribor rate, or other risk-free assets, such as the Treasury Bill or the German Bond. Accordingly, the relationship for the interest rate is

$$r = r^* + s, \qquad (2)$$

Equation (2) is well known, but I go one step further and assume that the spread can be analyzed into two parts. The first part is the fair or acceptable rate (s^*), which should be offered to a country, given its macroeconomic conditions, i.e., it is the spread under no speculation or underestimation, given the macroeconomic conditions. The second part, δ, can be regarded as a measure of underestimation or overestimation of the risk premium. If it is positive, it may reflect an extra risk premium that is charged based on the perceived subjective probability of default, or it could be regarded as a speculation rate, that is, a percentage that the markets offer in order to increase profits, to manipulate the government or to take advantage of the country's poor financial condition. If it is negative, then the markets have undervalued the spread, as they may have not assessed correctly the country's macroeconomic conditions, or they might want to tempt the government to issue more debt. Thus, the spread can be expressed as

$$s = s^* + \delta, \qquad (3)$$

Combining (2) and (3) yields

$$r = r^* + s^* + \delta, \qquad (4)$$

Equation (4) relates the market interest rate (r) to the risk-free rate (r^*), the "fair" spread (s^*), which should be offered, based on macroeconomic indicators, and an additional element (δ), which reflects risk based on factors other than the macroeconomic fundamentals. Equation (4) is a useful innovative formulation, because, in addition to the "fair" or acceptable spread rate in the risk premium, it incorporates a measure of speculation or error in the assessment of the risk premium.

The existence of (δ) has direct implications for the existence of the spread. If (δ) is different than zero then two state of affairs are created , which depend on whether the spread is overvalued or not. Thus two regimes are created denoting that there exists a threshold value in the process. In addition, (δ) as it is defined here, can be treated as an error term, justifying the random effects estimation.

3.3 The decision maker's preferences

I want to analyze the design of optimal policies in the presence of country risk given that the markets' perception is described by Equation (4). In this direction, I introduce the decision maker's attitude toward risk. I consider a decision maker, e.g., a government or a central bank that is fully informed about the macroeconomic condition of its country. The markets are also assumed to have full information, so that no information asymmetries exist between the government and the lenders. I also assume that markets are complete and that agents behave competitively.

In the present study, I present an alternative to the traditional approach to decision making by considering a decision maker whose preferences towards risk may vary over time, depending on the data and the circumstances. The traditional approach is the well-known expected utility theory, where economists model risk aversion as arising solely because the utility function over wealth is concave. The utility functions researchers typically use to model decision-making under risk are either linear (indicating risk neutrality) or concave to the origin (indicating an aversion to risk). This diminishing marginal utility of wealth theory of risk aversion is psychologically intuitive, and surely helps explain people's aversion to large-scale risk, since they dislike uncertainty in lifetime wealth; see Rabin (2000). However, it does not capture risk seeking attitudes, and does not incorporate the fact that people's decisions depend not only on the degree of uncertainty, but on its source as well.

The assumption that the decision maker's preferences should be strictly concave is an issue that contradicts the empirical evidence indicating people's unwillingness to fit the classical description of the risk neutrality or risk aversion. Expected utility theory does not incorporate convex preferences, which imply risk-seeking attitudes. As mentioned in Friedman and Savage (1948), experiences from real life situations indicate that people not only engage in fair games of chance, but they also engage freely and often eagerly in such unfair games as lotteries. Not only do risky occupations and risky investments not always yield a higher average return than relatively safe occupations or investments, but they frequently yield a much lower average return. In other words, people's preferences are strongly dependent on the level of risk exposure. With this in mind I address this specific type of risk attitude in my model and analyze the decision making process. In the macroeconomic literature, it is almost always assumed that all the economic agents have linear or concave preferences towards risk. Some researchers assume convex preferences, however. The proposed model in this study contributes to the latter literature.

Inspired mainly by the work of Friedman and Savage (1948), Kahneman and Tversky (1979, 1991, 1992), and others, like Rabin (2000), Rosenbladtt (2007), Kuznar (2002), and Alekseev (2000), I introduce a decision maker whose preferences are convex or concave relative to a reference point. The utility function is not strictly concave, but it has two parts: a strictly convex and a strictly concave part, thus exhibiting both risk loving and risk averting behavior, depending on the level of risk. This implies that agents value their prospects in terms of gains and losses relative to a reference point. They are loss averse, which means that they are more averse to losses than to gain seeking. As mentioned in Kahneman and Tversky (1992), one of the basic phenomena of choice under both risk and uncertainty is that losses loom larger than gains. The observed asymmetry between gains and losses is far too extreme to be explained by income effects or by decreasing risk aversion. In my view, in modern macroeconomics, agents do not act based only on the level of risk exposure, but they also behave in the context of gaining or loosing. This will be one of the basic notions that would discriminate my analysis from the related literature.

3.5 Model set up

I would like to adjust the formulation presented in Section 2.2 in order to introduce a decision maker with both convex and concave preferences depending on a reference point. The main goal of the decision maker is to optimize his/her sub-utility function, which depends on only one variable, the spread. To my knowledge, this formulation is new to the literature. Since the spread is linked to the total interest rate that someone will pay for a loan, it is reasonable to assume that people derive satisfaction or dissatisfaction depending on the assessed interest rate. The cost of borrowing affects both the budget of the consumers and the government, and improves or deteriorates the psychology of the market. In this sense, the social planner wants to optimize the country's utility function subject to a set of constraints that reflect the macroeconomic performance, in order to finance his/her program and provide optimism to the market.

I begin with a static model. I assume that the decision maker of a developed country derives utility from the spread offered to country and his/her preferences vary relative to a reference point. The formulation of the utility function that I adopt is similar, but not identical, to that of Kahneman and Tversky (1992). That is, I assume the following sub-utility function of the decision maker:

$$u(s) = \begin{cases} u^{-}(s) = -k(s - s^{*})^{b} & if \;\; s > s^{*} \\ u^{+}(s) = (-(s - s^{*}))^{a} & if \;\; s \leq s^{*} \end{cases} \tag{5}$$

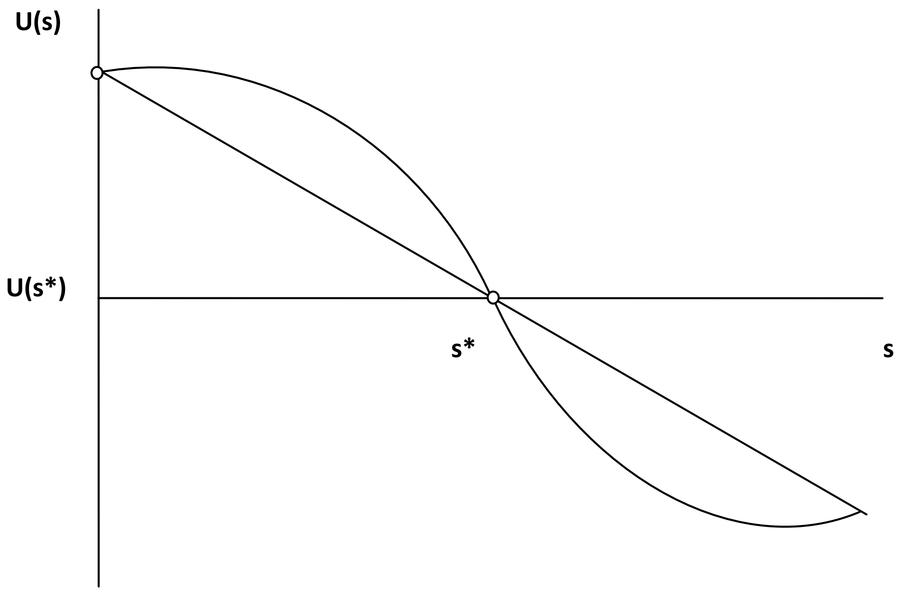
i.e., the decision maker maximizes a utility function that depends on the difference $s - s^{*}$, where s^{*} is the "fair" rate or "reference point," the most acceptable rate. This utility function is decreasing in *s*, since, as the spread rises, utility decreases. Assuming that k > 0, the function is everywhere continuous and s^{*} is a point of continuity since $\lim_{s \to s^{*-}} u(s) = \lim_{s \to s^{*+}} u(s) = u(s^{*})$.

The utility function can also be formulated in terms of *δ,* since from equation (4) we obtain $s - s^{*} > 0 \Rightarrow \delta > 0$, when speculation is present and $s - s^{*} \leq 0 \Rightarrow \delta \leq 0$, otherwise.

This formulation has direct implications for the curvature of the proposed utility function. Intuitively, I would like the upper part in Equation (5), where $s > s^{*}$, i.e. the area that the offered spread is higher than the acceptable-fair level, to be convex, implying risk seeking, and the lower part to be concave, implying risk aversion relative to the reference point. From my point of view this seems a reasonable assumption, indicating that the decision maker will avoid risk, when facing the "fair" or a lower than the "fair" spread. In terms of gains and losses, in the lower part, he/she gains, and thus exhibits risk aversion, since his/her motivation is to sustain the current condition. The fact that in the lower part the spread is equal to or lower than the "fair" rate implies healthy and stable macroeconomic conditions, so the social planner wants to retain macroeconomic stability, and hence he/she is risk averse.

On the other hand, in the presence of speculation, the decision maker becomes risk seeking, since in the framework of gains and losses he/she is losing. In this case, the relevant part of the utility function is the upper part, where $s > s^*$, i.e., in the regime of spreads higher than the maximum he would be willing to accept. The presence of speculation implies that the country's economic condition is not promising, a fact that creates difficulties in financing macroeconomic policy, which as a consequence might generate a risk seeking attitude. The above rationale can be represented schematically in Figure 4.

Figure 4 : Utility as a function of the spread



It is worth mentioning that there exists another possibility for the curvature of the utility function, which seems plausible. One might believe that the decision maker, in the presence of speculation, exhibits risk aversion. This implies that he/she does not take the risk to borrow at that moment from the capital markets and will attempt to improve the country's macroeconomic indicators in order to be able to borrow at a lower rate in the future. On the other hand, if the country's financial condition is underpriced then the decision maker reveals a risk seeking attitude, since he/she could borrow at a lower rate. This means that he/she might become risk-seeking in two ways: (i) by borrowing more that actually needed; and (ii) by being satisfied with the country's economic performance he/she might be tempted to relax macroeconomic policy. In this case, Figure 4 would have exactly the opposite curvature. Although a risk averse attitude seems possible in the presence of speculation ($\delta > 0$), it seems less reasonable to assume that a decision maker will exhibit risk seeking behavior while he/she is underpriced by the markets ($\delta \leq 0$). This is why I assume risk aversion when $\delta \leq 0$ and risk seeking when $\delta > 0$.

The proposed curvature is in line with the one presented by Kahneman and Tversky (1992), which suggests a value function, which is concave in the region of gains and convex in the region of losses. However, our difference with the present literature is that the proposed utility function is everywhere decreasing, and the curvature, relative to the reference point, due to the monotonicity is exactly the opposite, i.e. concave above the reference point and convex below. Note, that this does not affect the proposed preferences, which remain concave in the region winning and convex in the regime of losses..

The choice of the utility function's curvature imposes restrictions on the choice of the parameters *a*, *b*, and *k*. The first and second derivatives of (5) are:

$$u'(s)=\begin{cases}(u^-(s))'=-kb(s-s^*)^{b-1} & if\ \ s>s^* \\ (u^+(s))'=-a(-(s-s^*))^{a-1} & if\ \ s\le s^*\end{cases} \tag{6}$$

$$u''(s)=\begin{cases}(u^-(s))''=-kb(b-1)(s-s^*)^{b-2} & if\ \ s>s^* \\ (u^+(s))''=a(a-1)(-(s-s^*))^{a-2} & if\ \ s\le s^*\end{cases} \tag{7}$$

The function is everywhere decreasing when the first derivative is negative for both parts. Since we have already assumed that $k > 0$, it follows that $u'(s) < 0$ requires that $a > 0$ and $b > 0$. Furthermore, I have chosen the upper branch of the function (the lower in the figure) to be convex, hence the second derivative should be positive, which requires $0 < b < 1$. On the other hand, the lower branch is concave hence, the second derivative should be negative, which requires $0 < a < 1$. Note that s^* is a point of inflection since the curvature of $u(s)$ changes from concave to convex at that point. Whether the inflection point is stationary or not is an issue that should be examined further in relation with the restrictions imposed on *a*, *b*, and *k*.

Furthermore, the coefficient of relative risk aversion, which is defined as

$$r_R^-(\delta) = -\delta\frac{u''(\delta)}{u'(\delta)}$$

can be calculated with respect to δ, for the concave part, indicating a Constant Relative Risk Aversion coefficient,

$$r_R^-(\delta)=1-a \qquad \text{for } \delta<0 \tag{8}$$

In sum, I maximize the decision maker's utility function with respect to the assessed spread. As mentioned in Feder and Just (1977b), Eaton and Gersovitz (1980), and Sachs (1982), among others, the spread over LIBOR charged on Eurodollar loans reflects the probability of default of a particular country. In Section 2.5, I have presented an extensive survey of the literature about the benchmarks used in pricing government bond spreads. In my analysis I have chosen to use the Libor over Euro as the benchmark variable.

Then, in accordance with the literature, e.g., Edwards (1984) and Feder and Just (1977), observed data on the spread can be used to estimate the effects of macroeconomic variables, such as the debt-to-GDP ratio, the fiscal surplus, the unemployment rate, the inflation rate, etc., on the perceived probability of default.

Towards this direction I should link the spread to the probability of default, by investigating the functional form of that probability. Following Edwards (1984), I assume that the spread is a function of the (subjective) probability of default, *p*. Consider a one period loan of amount K, where the interest rate charged is equal to the risk-free rate plus the spread. The borrower (that is, the country) repays the loan with probability 1-*p*, or defaults with probability *p*. If we follow the general approach of Feder and Just (1977b), which incorporates also other variables such as loan duration and loan volume, then the lender's objective is to maximize the expected utility by optimally choosing the interest margin (s). The outcome of the maximization procedure was,

$$s = \frac{\eta}{\eta - 1}\frac{1}{\theta}\frac{p}{1-p}\bar{h}\frac{u'(-\bar{h}L)}{u'(-s\theta L)}, \quad (9)$$

Where $\frac{\eta}{\eta-1}$, reflects the borrowers bargaining position where η is the elasticity of demand for loans, $\frac{1}{\theta}$ is a profitability parameter related to the discount rate and the loan duration, $\frac{p}{1-p}$ is reflecting all aspects of the associated risk, where (*p)* is the probability of default, $\bar{h}$ is the expected loss which was assumed to take only one value and the term $\frac{u'(-\bar{h}L)}{u'(-s\theta L)}$ is the extra premium charged due to the risk aversion of the lender , where u is the utility function depending on the net revenue and L is the volume of the loan. This last term takes 1 for the risk neutral lender and is larger than 1 for the risk averse lender. Assuming for risk neutrality of the lenders side, the equation becomes,

$$s = \frac{\eta}{\eta-1}\frac{\bar{h}}{\theta}\frac{p}{1-p} \qquad (9)'$$

In my study I consider the simplest case and I do not take into account other variables that might be affected when the default occurs, such as the loan duration, the penalty that must be paid to the lenders because of the default and other liquidity constraints. Following Feder and Just (1977b), Edwards (1984), Bassat and Gottlieb (1992), and Ozdemir (2004), i assume that in the case of default the capital and the risk-free rate are completely lost and if we do not take into account the loan duration then, given the situation of uncertainty and risk neutrality for the lenders and perfect competition, the relationship $\frac{\eta\bar{h}}{(\eta-1)\theta} = 1$, stands.

An alternative argument is that under the previous assumptions the equilibrium condition will be $(1-p)(1+i) = (1+i^*)$, implying that the lender is indifferent between gaining the return of the asset $(1+i)$ with probability $(1-p)$ and the return of the risk-free rate $(1+i^*)$ with certainty.[6]

In the light of the above, the optimal spread is

$$s = \frac{p}{1-p}\gamma. \qquad (10)$$

[6] I am grateful to Professor Noulas, for providing me with this argument

This solution can be viewed as the solution to the optimization problem that I propose, i.e.,

$$\max u(s) = \max \begin{cases} u^{-}(s) = -k(s - s^{*})^{b} & if \;\; s > s^{*} \\ u^{+}(s) = (-(s - s^{*}))^{a} & if \;\; s \le s^{*} \end{cases}$$

$s.t.$

$$s = \frac{p}{1-p}\gamma$$

From Equation (10) it is straightforward that the spread is a function of the (subjective) probability of default, *p*. The variable γ captures other elements than the macroeconomic and institutional indicators affecting *s*, such as the risk free interest rate. I assume that $\gamma = 1 + r^{*}$, where r^* is the risk-free rate (Edwards, 1984). Other formulations are also possible, which incorporate issues as the loan volume, liquidity constraints or the penalty that has to be paid in the case of default, see (Feder and Just 1977a, b). The variable γ, since it contains the r^*, serves as an external global shock incorporating global changes to the interactional capital market. The analysis of Chapter 1 explains the importance of this variable to the spread determination.

Note, that in the evaluation of outcomes, the reference point serves as a boundary that distinguishes gains from losses (Kahneman and Tversky, 1992). In the evaluation of uncertainty, there are two natural boundaries, namely certainty and impossibility, which correspond to the endpoints of the certainty scale. Diminishing sensitivity entails that the impact of a given change in probability diminishes with its distance from the boundary.

Furthermore, the risk of default is the main factor determining the market spread. The function for *p* can be regarded as the markets' subjective probability of default based on available economic data for the determinants of the country's macroeconomic health. If *p* is a function of a vector *x* consisting of macroeconomic variables, then the choice of these variables is important for the estimation of the probability of default and thus of the spread.

As presented in detail in Chapter 1, the empirical analysis of the determinants of the default risk premium is essential for several reasons. First, an understanding of the factors that influence lending behavior is useful for policy making in borrowing countries. With this knowledge government can take the necessary steps towards managing their economies in a way such that the perceived default risk is kept at a level compatible with what lenders think is prudent. Second, additional information on how the market assesses default risk will be helpful for determining the probability that possible repayment difficulties can be transformed in to a major global crisis. And third, empirical information on the relationship between the level of government debt and other critical variables and their cost is useful for the analysis of optimal strategies.

Furthermore, observations on subjective probabilities are not available, while data on economic indicators can be used to estimate $p(x)$ (Feder and Just, 1977b). To do this it is necessary to specify a functional form for the function $p(x)$. Such a functional form should be bounded between zero and one for all choices of x. One of the most widely used formulations for probabilistic functions that satisfy these conditions is the logistic form; see Cox (1970). That is,

$$p(x) = \frac{\exp(\beta_0 + \sum_{j=1}^{k} \beta_j x_j)}{1 + \exp(\beta_0 + \sum_{j=1}^{k} \beta_j x_j)} \quad (11)$$

where x is the k-dimensional vector of the explanatory variables that determine the probability of default, β_j are the associated coefficients. Then,

$$\frac{p(x)}{1-p(x)} = \exp(\beta_0 + \sum_{j=1}^{k} \beta_j x_j) \tag{12}$$

And by taking logarithms,

$$\log \frac{p(x)}{1-p(x)} = \beta_0 + \sum_{j=1}^{k} \beta_j x_j \tag{13}$$

implying that the logarithm of the odds is linear in the parameters. Then the structural equation (10) may be written in logarithmic form as

$$\log s = \beta_0 + \sum_{j=1}^{k} \beta_j x_j + \log \gamma \tag{14}$$

This relation is made stochastic by adding an error term, ε_t. The precise definition of the error term is crucial, since it implies different variations of the model regarding the treatment of heterogeneity among countries and possible time effects.

Thus, I must choose the set of explanatory variables in the vector *x* and then investigate whether or not the optimal solution, s^*, forms a reference point in the decision making process. I will take this to be the case if I find two regimes in the spread function in that the coefficients of the variables in *x* differ in the two regimes.

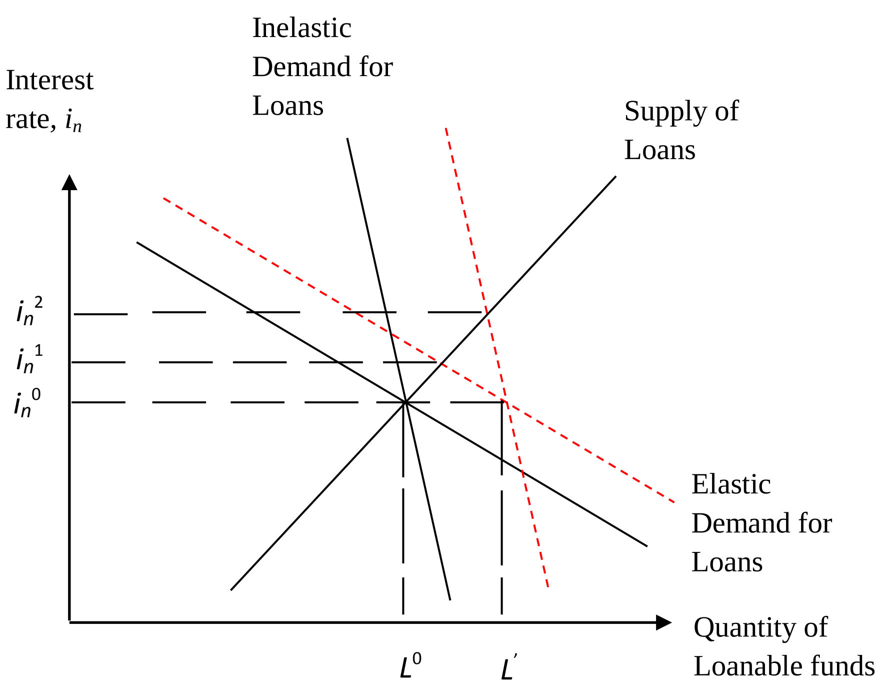
As I have presented in Chapters 1 and 2, there exists a large literature that investigates the explanatory variables that enter the vector *x*; see, among others, Edwards (1984), Feder and Just (1977a, b), Sachs and Cohen (1982), Sachs (1983), Eaton and Gersovitz (1980), Eaton, Gersovitz, and Stiglitz (1986), Frank and Cline (1971), Cantor and Packer (1996), McDonald (1982), Min (1998), Taffler and Abassi (1984), Baldacci, Gupta, and Mati (2008), and Afonso, Gomes, and Rother (2007).

Many authors attempt to divide the variables in *x* into blocks that have been found to have a significant impact on bond spreads, namely, solvency and liquidity, global financial conditions, fiscal vulnerability, political risk, competitiveness and transparency. Others divide them in four groups according to macroeconomic performance, government performance, external balance, and other variables. In the next chapter I am about to introduce the variables that form the vector of the spread determinants.

3.6 The elasticity of the demand for loans under risk preferences

As we have seen in the previous section, the elasticity of the demand for loans as a determining factor in the spread function has been addressed in Feder and Just (1977b). Here, I link the elasticity of the demand for loans to the preferences of the borrower towards risk. I assume that the demand for loans of a risk lover is less elastic than that of a risk averse borrower, so for a given rise in interest rates, the quantity demanded will decline less for the risk lover. Thus, if both borrowers increase their demand for funds by the same amount, the risk lover will end up paying higher interest than the risk averse. See Figure 2 below.

Figure 5: The elasticity of the demand for loans and its effect on the spread



Let the market for loanable funds be initially in equilibrium at point (L^0, i_n^0), and assume that both borrowers, the risk averse and the risk lover, increase their demand for funds by the same amount. For example, at the initial interest rate (i_n^0), quantity demanded by each borrower is larger than before by L'- L^0. The risk lover will end up paying higher interest (i_n^2) than the risk averse (i_n^1).

Furthermore, if the elasticity of the demand for loans with respect to the spread is assumed small, i.e., less elastic for the risk seeker, then for the system to come back to the equilibrium position a greater increase in the spread is required. On the other hand, if we assume that the elasticity of the demand for loans with respect to the spread is high, i.e., more elastic for the risk averse decision maker, then small adjustments are required to the spread in order to bring the system back to equilibrium. This rationale will be helpful in explaining the difference in the impact between the two regimes, with respect to the preferences towards risk.

As I have noted in section 3.3, when the borrower is losing, he/she behaving as a risk seeker, and when he/she is winning, he/she is exhibiting risk-averse behavior. Thus, lenders require an extra premium, which is translated as a higher spread. As an example, countries seek credit to finance actions so as to reduce unemployment. This will lead to an increase of the spread in any case. This increase is expected to be higher in the region of high spreads, as the country's economy is not so healthy, so the markets require an even higher premium to compensate for their extra risk exposure. Thus, a borrower seeking credit in the regime of high spreads, where he/she is losing, he/she behaves as a risk-lover, since he/she is aware that the he will be charged extra.

CHAPTER 4: ECONOMETRIC ANALYSIS

4.1 Introduction

I proceed with the econometric analysis of the model specified in the previous Chapter. Again, I use a small number of explanatory variables in the spread function, namely, the inflation rate, the debt-to-GDP ratio, the rate of growth of real GDP, the primary surplus, the unemployment rate, public investment, a risk free interest rate inside γ in Equation (14) of Chapter 3, namely, the long-run interest rate of Germany, to capture shocks in the global economy, as well as quality-of-institutions variables such as government effectiveness, control of corruption, political stability and regulatory law, regulatory quality and voice and accountability.

In order to assess the spread series, I have used the Libor over Euro as a proxy, and the new variable, the MINRFB, which is defined as the minimum risk free benchmark each year, between the German, the Libor, and the 10-year Treasury Rate, was used only for robustness purposes.

I use two unbalanced panel data sets to estimate the model and test the hypothesis of the existence of a threshold in government bond spread dynamics. An advantage of using panel over cross sectional data is that we can take into account differences across individual countries.

I begin with the description of the two data sets (Section 4.2). Then, in Section 4.3, I apply a battery of panel unit-root tests to test the hypothesis of stationarity of the variables used in estimation. Finally, in Section 4.4, I apply appropriate econometric methods to estimate the parameters of the model and test the theory exposed in the previous Chapters. In the end of the Chapter, I interpret the findings of the empirical analysis.

4.2 The two data sets

The first data set consists of 11 Eurozone countries (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, and Spain) over the time period 1997-2014. Data from this group of countries have been used by various papers, such as Barrios, et al (2009). The selection of this specific set of countries was imposed by the limitations of data availability, mainly for the Baltic countries, which only joined the euro area in recent years, and reliability issues, especially for the case of Luxemburg. The macroeconomic data for this group of countries were collected from the Eurostat Database.

The second data set consists of the 32 OECD member states over the time period 1996-2014. It contains the above 11 Eurozone countries and 21 more countries (Australia, Canada, Chile, Czech Republic, Denmark, Hungary, Israel, Japan, Korea, Luxembourg, Mexico, New Zealand, Norway, Poland, Slovak Republic, Slovenia, Sweden, Switzerland, United Kingdom, and the United States). The frequency (annual) was imposed by the availability of the data. Note also that because of the difficulty to find reliable data, I had to collect the data from various sources. For this data set, the major sources were the OECD and the World Bank. The 10-year government bond yields, the Libor rate over Euro, and the 10-year Treasury Bill series were obtained from the Federal Reserve Bank of St. Louis (FRED). The risk-free rate, i.e. the Germany's long run interest rate was provided by the European Central Bank (ECB). The data for the quality-of-institution variables were taken from the World Bank. I used several definitions of the spreads to optimize my results.

The full set of variables used in my analysis is as follows: (1) the 10-year government bond yield (denoted as YIELDS) and its logarithm (LOGYIELDS); (2) the spread over the German long-run interest rate (SPREADGER) and its logarithm

(LSPREADGER); (3) the spread over Libor (LIBOR) and its logarithm (LSLIBOR); (4) the minimum-spread variable (MINSPREAD) and its logarithm (LMINSREAD), proxied by the variable MINRFB; the dummy variable (DUMMY) for the threshold, which takes on the value of 1, for values of the spread that are greater than the threshold and 0, for values that are lower than or equal to the threshold; whereas the threshold that has been used is the rating based threshold (DUMMYR), which has been defined as the average spread of the associated rating class that each country belongs to, which serves as the fair price and creates the reference point. The other two alternative dummy variables, namely the ones that create the threshold using the average spread of the 11 EU countries and the weighted average are denoted as (DUMMYM) and (DUMMYW), respectively (5) the mean yield rate of 10-year government bond of the associated rating class, which alternatively serves as the fair price and creates the reference point (YIELDSTAR); (6) the gamma variable (GAMMA) and its logarithm (LGAMMA), which is one plus the risk-free interest rate; (7) the risk-free long-run interest rate of Germany, to count for external shocks in international markets; (8) the inflation rate (INFL); (9) the debt-to-GDP ratio (DEBTGDP) and its logarithm (LDEBTGDP); (10) the GDP growth rate (GDPGRO); (11) the primary surplus (PRIMBS)for the first data set and the total surplus (also denoted as PRIMBS) for the second and (12) the unemployment rate (UR); (13) public investment (PUBINV); and indices of quality of institutions, e.g., (14) government effectiveness (GOVEFFECT), (15) control of corruption (CORRU), (16) political stability (POLSTAB), (17) regulatory law (RLAW), (18) regulatory quality and (10) voice and accountability.

4.3 Panel unit-root tests

In this section, I use unit-root tests to test for stationarity of the variables, which is a crucial assumption in my empirical analysis. Because of the use of panel data, the time dimension (*T*) and the number of cross sections (i.e., the number of countries, *N*) are important (Greene, 2008, p. 767), so I test for stationarity in both data sets. Furthermore, it has long been recognized that estimated regression relations can be distorted by non-stationarity of the data, so I use many unit-root tests (Greene, 2008, p. 243), namely: (1) the Levin, Lin, and Chu (2002) (LLC) test; (2) the Breitung (2000) test; (3) the Hadri (2000) test; (4) the Im, Pesaran, and Shin (2003) (IPS) test; (5) the Fisher-type Augmented Dickey-Fuller (ADF) test; and (6) the Fisher - type Phillips-Peron (PP) test (Maddala and Wu, 1999).

I begin by classifying our unit root tests on the basis of whether there are restrictions on the autoregressive process across cross-sections or series. If ρ_i are the autoregressive coefficients, then the Levin, Lin, and Chu (LLC), Breitung, and Hadri tests employ the assumption that the persistence parameters are common across cross-sections so that $\rho_i = \rho$ for all *i*. Alternatively, one can allow ρ_i to vary freely across cross-sections. The Im, Pesaran, and Shin (IPS), and Fisher-ADF and Fisher-PP tests are of this form. Levin, Lin, and Chu (LLC), Breitung, and Hadri tests all assume that there is a common unit root process so that ρ_i is identical across cross-sections. On the other hand the IPS, Fisher-ADF and Fisher-PP tests allow for individual unit-root processes that vary across cross-sections.

Further classifications can be made on the basis of the null hypothesis assumption. The Levin, Lin, and Chu (LLC), Breitung, Harris Tzavalis, The Im, Pesaran, and Shin (2003) employ a null hypothesis of a unit root, while the Hadri test uses a null of no unit root. I provide a brief review of the background mathematics and the statistics used for each test separately.

The Levin, Lin, and Chu (2002) (LLC) allow of individual deterministic effects and heterogeneous serial correlation structure of the error terms assuming homogeneous first order autoregressive parameters. They assume that both N and T tend to infinity, but T increases at a faster rate, such that $N / T \to 0$. They test the hypothesis that each individual time series contains a unit root against the alternative hypothesis that each time series is stationary. LLC show that under the null, a modified t-statistic is asymptotically normally distributed.

The Breitung methods vary from LLC in two distinct ways. First, only the autoregressive portion (and not the exogenous components) is removed when constructing the standardized proxies, and second, the proxies are transformed and detrended. Likewise with the LLC test, in the Breitung test the t-statistic for the resulting estimator has in the limit a standard normal distribution.

The panel unit root tests from Harris and Tzavalis (1999). This also has a null of unit root versus an alternative of stationarity. It is designed for data sets that have a relatively short T. In order to provide relatively exact corrections for small values, they very tightly restrict the model to exclude the augmenting lags. Thus if the original panel is unbalanced (which they require), it will remain so. They also assume a homogeneous variance, which the Levin-Lin test doesn't. Hadri (2000) proposes a test where the null is stationarity. This is a generalization of the KPSS test (Kwiatkowski, Phillips, Schmidt, and Shin, 1992) for a single time series. Like the KPSS test, the Hadri test is based on the residuals from the individual OLS regressions on a constant, or on aconstant and a trend. The test derives a residual-based Lagrange multiplier (LM) test, where the null hypothesis is that there is no unit root in any of the series in the panel against the alternative of a unit root in the panel. The Z1-statistic is based on LM1, which assumes homoskedastic errors, while the Z2-statistic is based on LM2, which is heteroskedasticity consistent. However, simulation evidence suggests that in various settings (for example, small T), Hadri's panel unit root test experiences significant size distortion in the presence of autocorrelation when there is no unit root.

The Im, Pesaran, and Shin (2003) test, unlike the LLC ant the Harris-Tzavalis test, allow the more general alternative that the ρ_i can vary from cross-section to cross-section and, in fact, that some cross-sectional units can have a unit root. However, due to this assumption, the power of the test diminishes quite severely if a substantial fraction of cross-sectional units have a unit root. They compute separate ADF test statistics on each cross-section. The IPS t-bar statistic is defined as the average of the individual ADF statistics and converges to a standard normal variate as $\mathrm{N} \to \infty$ under the null hypothesis.

The Pedroni test (1999, 2004) proposed several tests for the null hypothesis of cointegration in a panel data model, which allows for considerable heterogeneity. Pedroni considered the following type of regression: $y_{it} = a_i + \delta_t + x'_{it}\beta_i + e_{it}$,for a time series panel of observable y_{it} and x'_{it}. The variables y_{it} and x'_{it} are assumed to be I(1), for each member i of the panel, and under the null of no cointegration the residual e will also be I(1). The parameters a_i and δ_t allow for the possibility of individual specific fixed effects and time effects, respectively. The slope coefficients β_i are also permitted to vary by individual, so that in general the cointegrating vectors may be heterogeneous across members of the panel.

The last type of tests I have used were Fisher-ADF and Fisher-PP tests, which combine the *p*-values from unit root tests for each cross-section to test for a unit root in the panel data. The asymptotic distribution of the test statistics is chi-square (χ^2) with 2*N* degrees of freedom, where *N* is the number of cross-sections. The null and the alternative hypotheses are formed as in the IPS test.

I have implemented these unit root tests using two different computer programs, namely EViews 9.0 and WinRats 9.0. Table 4.1 presents the results from the unit-root tests for the first data set (the 11 Eurozone countries) and Table 4.2 presents the results for the second data set (the 32 OECD countries). The tests allowed for individual constants or individual constants and time trends. I present the value of each test statistic. The corresponding p-values, are denoted with the number of the star, where ***, **, and * indicate statistical significance at the 1, 5, and 10-percent level, respectively.

As shown in Table 4.1,the results of the tests vary depending on the variable and the option that has been chosen. What is important though, is that, for each variable, stationarity is supported by at least one unit-root test, so I conclude that all the variables can be considered to be I(0). As an example for the 11 Eurozone countries data set, the series LSLIBOR is found to be stationary using the Hadri test at 10-percent level, whereas in the second data set (the OECD countries) is stationary using the Hadri and the Breitung test at 1-percent level, and at 5-percentlevel using the Fisher-ADF. I have also conducted the same tests for the first differences of the variables, and found that all of them are stationary. The results for the unit root tests for the second data set (reported in Table 4.2) appear to be similar, suggesting stationarity of the levels of the variables by at least one test. The same conclusion is also true for the quality-of-institutions variables, but, for space considerations, I do not report the results in Tables 4.1 and 4.2.

Table 4.1 Panel unit-root test results for the 11 Eurozone countries

Test \ Variable		*LSLIBOR*	*LMINSPREAD*	*LSPREADGER*	*LGAMMA*	*INFL*	*DEBTGDP*	*UR*	*PRIMBS*	*GDPGRO*
LLC	t^*_c	4.05	-4.8***	-3.5***	6	-5.9***	-1.31*	-2.89**	-2.73**	-4.92***
	t^*_t	11.88	-4.0***	0.5	-5.61***	-6.89***	-1.89**	-3.38***	-3.82***	-6.59***
Breitung	t^*_c	-	0.65	-	-1.96***	-				
	t^*_t	0.21	-8.03***	-	6.07	2.57	2.55	0.91	-3.95***	-3.15***
Hadri	$Z_{2\,c}$	2.17*	2.71**	4.36	17.82	8.09	5.14	3.95	5.28	6.7
	$Z_{2\,t}$	4.95	6.04	11.74	5.56	6.76	4.63	7.78	1.9	4.89
HarrisTzavalis	Z_c	-	-4.27***	-	-0.53	-10.7***	2.14	2.46	-3.48***	-6.14***
	Z_t	-	-1.06	-	-2.95**	-6.58***	2.06	2.76	-2.41**	-6.19***
IPS	W_c	1.48	-1.71**	-1.35*	-1.38*	-5.13***	0.53	-2.78**	-1.87**	-3.25***
	W_t	3.65	-0.2	0.11	-0.67	-4.4***	1.23	-1.2	-2.71**	-4.64***
Fisher-ADF	χ^2_c	16.5	43.21***	104***	0.17	69.97***	20.07	43.23***	34.09**	46.02***
	χ^2_t	6.15	72.1**	72.1**	26.95	59.52***	15.87	32.64*	40.70**	60.89***
Fisher-PP	χ^2_c	16.35	31.19*	106***	1.04	70.7***	15.81	20.1	29.07	58.35***
	χ^2_t	6.57	17.2	66.7*	37.7	61.56***	7.01	9.43	24.79	106.81***
Pedroni	*IPS* ADF_c	6.98	6.06	-	6.06	6.06	6.06	6.06	6.06	6.06
	IPS ADF_t	13.3	9.66	-	9.66	9.66	9.66	9.66	9.66	9.66
Decision	I(0) / I(1)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)

Notes: *(1) the subscripts c and t indicate the option of individual constant and individual constant and time trend, respectively; (2) in the LLC, Breitung, IPS, and Fisher-ADF tests, the lag length in each cross-section ADF regression is chosen by the Schwartz criterion; (3) in the LLC, Hadri, and Fisher-PP tests, a kernel-based consistent estimator of the residual covariance is obtained using the lag truncation parameter selection method of Newey and West (1994); (4) ***, **, and * indicate statistical significance at the 1-percent, 5-percent, and 10-percent level, respectively.*

Table 4.2 Panel unit-root test results for the 32 OECD countries

Test	Variable	*LSLIBOR*	*LMINSPREAD*	*LSPREADGER*	*LGAMMA*	*INFL*	*DEBTGDP*	*UR*	*PRIMBS*	*GDPGRO*
LLC	t^*_c	1.21	-9.19***	-3.67***	0.36	-6.88***	2.5	-5.43***	4.96	-9.89***
	t^*_t	3.05	-8.60***	0.34	2.19**	-6.58***	-0.23	-4.23***	4.15	-10.85***
Breitung	t^*_c	-	-	-	-	-	-	-	-	-
	t^*_t	-3.45***	-7.92***	-1.37*	3.34	2.12**	6.1	-5.70***	-8.33***	-
Hadri	Z_{2c}	-0.30***	1.17***	1.56	8.59	12.94	10.75	5.76	13.02	8.26
	Z_{2t}	5.96	6.71	9.18	11.47	12.16	11.05	4.95	11.09	6.78
HarrisTzavalis	Z_c	-	-7.40***	-	0.43	-10.40***	-	1.94	-	-17.61***
	Z_t	-	-	-	-13.43***	-6.32***	-	4.07	-	-12.67***
IPS	W_c	-0.69	-7.40***	-3.48***	3.28	-7.02***	4.9	-4.84***	-2.01**	-7.10***
	W_t	1.52	-4.82***	-1.29*	2.27	-5.11***	4.5	-4.04***	-4.60***	-6.92***
Fisher-ADF	χ^2_c	83.54**	171.81***	101.10***	31.73	164.86***	27.21	124.52***	68.78	162.21***
	χ^2_t	60.91	133.58***	89.30***	37.7	130.37***	25.81	113.17***	112.56***	158.63***
Fisher-PP	χ^2_c	64.02	98.98***	146.79***	25.98	504.42***	22.2	101.14***	65.02	207.95***
	χ^2_t	32.93	62.65	163.89***	38.78	217.18***	29.35	87.02**	54.27	279.36***
Pedroni	*IPS* ADF_c	-	-	-	-	-	3.13	-	-	-
	IPS ADF_t	-	-	-	-	-	-37.88***	-5.14***	-12.30***	-14.54***
Decision	I(0) / I(1)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)

Notes: *(1) the subscripts c and t indicate the option of individual constant and individual constant and time trend, respectively; (2) in the LLC, Breitung, IPS, and Fisher-ADF tests, the lag length in each cross-section ADF regression is chosen by the Schwartz criterion; (3) in the LLC, Hadri, and Fisher-PP tests, a kernel-based consistent estimator of the residual covariance is obtained using the lag truncation parameter selection method of Newey and West (1994); (4) ***, **, and * indicate statistical significance at the 1-percent, 5-percent, and 10-percent level, respectively.*

4.4 A threshold model

In a threshold regression model, the idea is to check whether the regression coefficients are stable across the appropriately selected regimes. Following Hansen (2000), a typical regime-depended modeling approach can begin by considering the following two equations:

$$y_i = \theta_1^{'}\chi_i + e_i, \qquad q_i > \gamma$$
$$y_i = \theta_2^{'}\chi_i + e_i, \qquad q_i \le \gamma \tag{15}$$

where q_i is the threshold and is used to split the sample into two groups, which we may call "classes," or "regimes," depending on the context. The random variable e_i is an error term. Two issues that require attention are the selection of the reference point and the input method. In my analysis, the mean spread (yield) for the 11 Eurozone countries, $s*$, serves as the reference point. Other approaches, such as Hamilton's (1989) Markov-switching models, compute the value of the threshold endogenously from the data. This approach does not seem to be appropriate here, however, as there are computational difficulties when working with panel data. In addition, the estimation of the threshold might turn out to be unstable. An exogenous definition of the threshold seems more appropriate for this study. In the present study, the above two equations are as follows:

$$\log s_{it} = \beta_0 + \sum_{j=1}^{k} \beta_j x_{it,j} + a \log \gamma_t, \qquad s_{it} > s_t*$$
$$\log s_{it} = \beta_0^{'} + \sum_{j=1}^{k} \beta_j^{'} x_{it,j} + a' \log \gamma_t \qquad s_{it} \le s_t*. \tag{16}$$

If a threshold value exists, then the estimated coefficients should be statistically significant in every state and should differ in the two regimes.

In order to incorporate the two states in one equation, I follow the procedure presented in Cassou, et al (2016). In particular, to indicate on which state of the spreads an observation lies, I use a dummy variable, denoted by I_{it}, to multiply each of the variables. Thus, in the case of the log-linear model, I get the following Threshold Regression Model, which can capture the asymmetric effects on the spread:

$$\log s_{it} = \sum_{j=1}^{k} [\beta_j I_{it} x_{it,j} \; + \; \beta_j^{'} (1 - I_{it}) x_{it,j}] + \alpha \log \gamma_t + \varepsilon_{it}, \tag{17}$$

where the dummy variable is defined as

$$I_{it} = \begin{cases} 1 & if \;\; s_{it} > s_t * \\ 0 & if \;\; s_{it} \leq s_t *, \end{cases} \tag{18}$$

4.4.1 The nonlinear case

I begin with the nonlinear model, i.e., the equation obtained from the literature without any transformation applied to it, namely (10),

$$s = \frac{p}{1-p}\gamma,$$

and substitute from (12),

$$\frac{p(x_{it})}{1-p(x_{it})} = \exp(\sum_{j=1}^{k} \beta_j x_{it,j}),$$

to obtain

$$s_{it} = \gamma_t \exp(\sum_{j=1}^{k} \beta_j x_{it,j}), \tag{19}$$

By dividing with gamma, thus exploiting the restriction that the coefficient of gamma is equal to one, I obtain the following equation:

$$\frac{s_{it}}{\gamma_t} = \exp(\sum_{j=1}^{k} \beta_j x_{it,j}), \tag{20}$$

This is the nonlinear model. It seems preferable to estimate this equation, instead of its log-linear transformation, because, as Gallant (1987, p. 427) points out, although transformations of this kind are plausible, in an attempt to make the error term more nearly normally distributed, nevertheless they might destroy consistency or redefine population parameters. The nonlinear threshold model is then

$$\frac{s_{it}}{\gamma_t} = \exp[\sum_{j=1}^{k} \beta_j I_{it} x_{it,j} + \beta_j'(1\text{-}I_{it}) x_{it,j}] + \varepsilon_{it} \ , \tag{21}$$

In the nonlinear case, I model heterogeneity, that is country-specific effects, as fixed effects. The fixed effects formulation or the so-called Dummy Variable Model implies that differences across countries can be captured as differences in the constant term, which are treated as unknown parameters to be estimated, under the assumption of homoskedasticity. With this set up the model can be treated as an ordinary linear model and can be estimated by least squares with standard errors that are robust to heteroskedasticity and serial correlation. Thus, the estimating equation is

$$\frac{s_{it}}{\gamma_t} = \exp[\sum_{j=1}^{k} \beta_j I_{it} x_{it,j} + \beta_j'(1\text{-}I_{it}) x_{it,j} + \sum_{i=1}^{N-1} \delta_i D_i] + \varepsilon_{it} \ , \tag{22}$$

where D_i is the dummy variable for country i. Substituting the variables of interest, I obtain the equation

$$\frac{s_{it}}{\gamma_t} = \exp[\sum_{i=1}^{N-1} \theta_i D_i + \beta_1 DUMMY_{it} + \beta_2 DINFL_{it} + \beta_3 DDEBTGDP_{it} + \beta_4 DGDPGRO_{it}$$

$$+ \beta_5 DPRIMBS_{it} + \beta_6 DUR_{it} + \beta_7 DCORRU_{it} + \beta_8 DRLAW_{it} + \beta_9 DREGQUALITY_{it} + + \beta_{10} DGOVEFFECT_{it}$$

$$+ \beta_{11} DPOLSTAB_{it} + \beta_{12} DVACOUNT_{it} + \beta_{13} DPUBINV_{it} + \beta_{14} D1_{it} + + \beta_{15} D1INFL_{it} + \beta_{16} D1DEBTGDP_{it}$$

$$+ \beta_{17} D1GDPGRO_{it} + \beta_{18} D1PRIMBS_{it} + \beta_{19} D1UR_{it} + \beta_{20} D1CORRU_{it} + \beta_{21} D1RLAW_{it} + \beta_{22} D1REGQUALITY_{it}$$

$$+ \beta_{23} D1GOVEFFECT_{it} + \beta_{24} D1POLSTAB_{it} + \beta_{25} D1VACOUNT_{it} + \beta_{26} D1PUBINV_{it}] + \varepsilon_{it}, \tag{23}$$

where DINFL = DUMMY×INFL, DDEBTGDP = DUMMY×DEBTGDP, DGDPGRO = DUMMY×GDPGRO, DPRIMBS = DUMMY×PRIMBS, DUR = DUMMY×UR, DCORRU = DUMMY*CORRU, DRLAW = DUMMY*RLAW, DREGQUALITY = DUMMY*REGQUALITY, DGOVEFFECT=DUMMY* GOVEFFECT, DPOLSTAB = DUMMY*POLSTAB, DVACOUNT = DUMMY* VACOUNT, DPRINV = DUMMY*PRINV, DPUBINV = DUMMY*PUBINV, D1 = 1 – DUMMY, and the rest of the variables are defined in a similar manner, i.e. D1INFL = D1×INFL and so on.

In this Section, I estimate Equation (23) using nonlinear least squares (NLLS) provided by the econometric software WinRATS 9.0. This method uses the Gauss-Newton iterative algorithm for nonlinear estimation. As a starting value for each parameter, I used zero. I also used the option that produces panel-clustered standard errors, which are robust to heteroscedasticity and serial correlation of the errors.

First, consider the estimates obtained from the first data set (the 11 Eurozone countries). For a fairly thorough investigation for the existence of a threshold, I have used the same spread series, namely the spread over Libor (LIBOR), proxied by the rating based threshold. The spread over Libor (LIBOR), created from the mean of the Eurozone spreads, was used for robustness purposes. The original results with the MINRFB benchmark are presented in the Appendix.[7] In Table 4.3, I present the results for the spread over Libor with rating based threshold and mean value threshold.

The initial results were promising. I have dropped from the regression the insignificant variables at 10-percent level, one at a time, and obtained a regression

[7] Initially, I have used three spread series, namely the spread over the German long-term interest rate (SPREADGER), the spread over Libor (LIBOR), and the MINSPREAD series only for robustness purposes which are presented in the Appendix.

with a set of variables that are all significant. Strong evidence of diversification between the two regimes was noticed, while most of the variables were statistically significant at 1-percent level. The final results are reported in Table 4.3.

Table 4.3 Nonlinear regression for the 11 Eurozone countries

Spread Series: LIBOR / Threshold: Rating Based
Nonlinear Least Squares - Estimation by Gauss-Newton
Convergence in 22 Iterations.
With Clustered Standard Error Calculations

	Variables	Coefficient	t-Statistic
1	DUMMY	-5.686 ***	-18.476
2	DINFL	17.836 ***	3.972
3	DGDPGRO	-9.214 ***	-8.103
4	DPRIMBS	-2.355	1.193
5	DUR	14.494 ***	10.374
6	DPRINV	-0.002 ***	2.801
- - -	- - -	- - -	- - -
7	D1	--3.726 ***	-9.607
8	D1INFL	8.438 *	1.689
9	D1PRIMBS	-21.452 ***	-5.917
10	D1RLAW	-1.044 ***	-5.052

Spread Series: LIBOR / Threshold: Mean value
Nonlinear Least Squares - Estimation by Gauss-Newton
Convergence in 24 Iterations.
With Clustered Standard Error Calculations

	Variables	Coefficient	t-Statistic
1	DUMMY	-5.815 ***	-19.353
2	DINFL	25.545 ***	3.673
3	DGDPGRO	-9.257 ***	-9.008
4	DUR	13.352 ***	9.645
- - -	- - -	- - -	- - -
5	D1	-4.669 ***	-51.819
6	D1PRIMBS	-12.547 ***	-8.470
7	D1UR	8.376 ***	6.385

*Notes: (1) The dashed line is for distinguishing the two regimes. (2) The superscripts ***, **, and * indicate statistical significance at the 1-percent, 5-percent, and 10-percent level, respectively. I retained the variable DPRIMBS, because its t-statistics is larger than one in absolute value.*

Convergence was achieved in 22 iterations for the regression using the LIBOR (with the rating based threshold) and in 24 iterations using the LIBOR (with the mean threshold). All variables are now statistically significant at the 1-percent level and the signs of the variables are the expected ones. First, the inflation rate is expected to influence the spread positively (the Fisher effect). Second, the debt-to-GDP ratio, which appears insignificant in the above Table, is also expected to influence the spread positively, as an increase in the indebtedness of the country will raise the probability of default, which leads to higher spreads. Third, the GDP growth rate reflects the rate of the country's economic development and is expected to influence the spread negatively, since higher growth rates improve the countries creditworthiness. Fourth, the fiscal variables i.e. the primary surplus used for the first data set and the total surplus used for the second data set, are expected to have a negative effect on the spread because it reflects the ability of debt servicing. Fifth, the rate of unemployment is expected to influence the spread positively as it is a quality index that reflects the country's macroeconomic health. Sixth, public investment is expected to influence the spread negatively. Seventh, negative effect for all of the quality-of-institutions indicators (political stability, regulatory law, control of corruption, and government effectiveness), as higher values of these variables indicate better quality of institutions.

The results support the hypothesis that a threshold value exists. First, for the regression with rating based threshold the set of explanatory variables is different in the two branches, namely, *DUMMY, DINFL, DGDPGRO, DUR, and DPRINV*, in the upper part, whereas we decided to keep *D*1*PRIMBS* since his t-statistic is larger than one, and *D*1, *D1INFL, D*1*PRIMBS*, and *D1RLAW* in the lower part. Second, the estimated coefficients of the same variables vary, indicating different impact of the variables on the spread. For instance, the coefficient of the inflation rate is 17.836 in the upper branch and 8.438 in the lower. Using the Libor with the mean threshold, the results are similar regarding the existence of the threshold. It appeared that the variables *DUMMY, DINFL, DGDPGRO,DUR* were common in the upper part and *D1, D1PRIMBS and D1UR* in the lower part.

Using the same method, I estimate Equation (23) with the second data set (the 32 OECD countries). Table 4.4 reports the results. Again the results suggest the presence of a threshold value. The set of variables in the two regimes is again different. All variables are significant in the upper part, while two of them have been dropped from the lower part (the inflation rate and the primary surplus). The signs are similar for both data sets. Again, there exists a difference between the coefficients of the variables that are present in both states. Note that the value of the Durbin-Watson statistic is low (1.35), indicating that serial correlation is present. Although the estimation method produces standard errors that are robust to serial correlation, this issue will be addressed later.

Table 4.4 Nonlinear regression for the 32 OECD countries

Spread Series : LIBOR / Threshold: Rating Based
Nonlinear Least Squares - Estimation by Gauss-Newton
Convergence in 19 Iterations.
With Clustered Standard Error Calculations

	Variables	Coefficient	t-Statistic
1	DUMMY	-4.443***	-17.047
2	DDEBTGDP	0.258	1.459
3	DGDPGRO	-8.634***	-3.689
4	DPRIMBS	-1.680	-0.974
5	DUR	5.451***	4.558
6	DPOLSTAB	-0.231*	-1.834

7	D1	-5.647***	-15.557
8	D1INFL	3.515	1.427
9	D1DEBTGDP	0.928***	6.601
10	D1PRIMBS	-2.601***	-3.937
11	D1UR	9.492***	4.779
12	D1CORRU	-0.202**	-1.988
13	D1POLSTAB	-0.157	-1.176
14	D1PUBINV	-0.041***	-5.013

*Notes: (1) The dashed line is for distinguishing the two regimes; (2) ***, **, and * indicate statistical significance at the 1-percent, 5-percent, and 10-percent level, respectively; (3) the p-values for the hypotheses that the coefficients of DDEBTGDP and D1INFL, are zero against two-sided alternatives are 0.147, 0.153 respectively; I retained also the variables DPRIMBS and D1POLSTAB, because their t-statistics are larger than one in absolute value.*

Next, I estimate Equation (23) by the Generalized Method of Moments (GMM), as some of the explanatory variables may be correlated with the error term. For example, a positive shock to the spread (that is, a high value of the error term ε_{it}) may cause the rate of unemployment and the debt-to-GDP ratio to rise and the rate of growth of real GDP to fall. The set of instrumental variables (IVs) employed contains the country dummies and two lags of each of the explanatory variables. I test the hypothesis of correct specification of the model and of valid IVs using Hansen's (1982) *J*-statistic, which is asymptotically distributed as a chi-square random variable with degrees of freedom equal to the number of IVs minus the number of estimated parameters. If Equation (23) is well specified and the IVs are valid, in that they are not correlated with the error term, the *J*-statistic should not reject the above hypothesis.The results for the above mentioned spread appears similar. The estimation results when the series are reported in Table 4.5.

Table 4.5 GMM results for the 11 Eurozone countries

Spread Series: LIBOR / Threshold: Rating Based	
GMM-Input Weight Matrix - Estimation by Gauss-Newton	
Convergence in 15 Iterations. Final criterion was 0.0000063 <= 0.0000100	
With Clustered Standard Error Calculations	
Panel(18) of Annual Data From 1//1999:01 To 11//2014:01	
Usable Observations	156
Degrees of Freedom	139
Skipped / Missing (from 196)	40
J-Specification(8)	1.776
Significance Level of J	1.000

	Variables	Coefficient	T-Stat
1	DUMMY	-330.906***	-462.762
2	DINFL	65.883***	6.0122
3	DPRIMBS	-6.297***	-3.251
4	DUR	28.077***	7.819
5	D1	-328.217***	-363.487
6	D1DEBTGDP	2.5286***	2.139
7	D1PRINV	-0.002	-1.278

*Notes: (1) The dashed line is for distinguishing the two regimes. (2) The superscripts ***, **, and * indicate statistical significance at the 1-percent, 5-percent, and 10-percent level, respectively. I retained the variable DPRINV, because the t-statistics is larger than one in absolute value.*

The GMM estimates are not unreasonable and support the hypothesis that a threshold value exists. Again, the set of explanatory variables is different in the two states, since the upper part contains the variables, *DUMMY*, *DINFL*, *DPRIMBS* and *DUR*, while the lower part contains only the variables *D*1, *D1DEBTGDP and D1PRINV*. Furthermore, the estimated coefficients have the expected sign and vary from one regime to another. We reached the same conclusions, i.e. not unreasonable results applying the same method to the second data set for the OECD countries.

4.4.2 The nonlinear case with partial adjustment

The presence of serial correlation, as the low values of the Durbin-Watson statistic indicate, might be interpreted as a sign of model misspecification. In this Section, I modify Equation (13) to incorporate the partial adjustment mechanism; see, e.g., Kmenta (1971 pp. 476-478). Let s^d denote the logarithm of the desired level of the spread, which is not directly observable, and assume that if there is a shock to it, a complete adjustment of the actual log spread, s, to its desired level is not achieved in a single period, because of technological constraints, institutional rigidities, and the like, but only a fraction δ of the difference $s_t^d - s_{t-1}$ is translated into a change in the actual log spread, $s_t - s_{t-1}$, where here δ is the "speed of adjustment" parameter. The closer the value of δ is to 1 the faster the speed of adjustment. This provides us with intuition about the swiftness with which the spread adjusts relative to changes in the spread determinants. That is,

$$s_{it} - s_{it-1} = \delta(s_{it}^d - s_{it-1}), \quad 0 < \delta \leq 1 \,, \tag{24}$$

The nonlinear counterpart of this mechanism is

$$\frac{s_{it}}{s_{it-1}} = \left(\frac{s_{it}^d}{s_{it-1}} \right)^{\delta} , \tag{25}$$

Where s is the level (not the logarithm of the level) of the spread. Modifying δ to vary from regime to regime, yields

$$\frac{s_{it}}{s_{it-1}} = \left(\frac{s_{it}^{d}}{s_{it-1}} \right)^{\delta_1 \mathrm{I}_{it} + \delta_2 (1-\mathrm{I}_{it})}, \tag{26}$$

where 0 <δ_1 ≤ 1and 0 <δ_2≤ 1.Upon rewriting Equation (10) with s^d on the left-hand side, that is,

$$s_{it}^{d} = \gamma_t \exp(\sum_{j=1}^{k} \beta_j x_{it,j}), \tag{27}$$

substituting into Equation (26), allowing for country specific effects and differences in the coefficients between the two regimes and adding an error term we obtain

$$s_{it} = \exp\left([\delta_1 I_{it} + \delta_2 (1 - I_{it})]\{\sum_{i=1}^{N-1} \theta_i D_i + \sum_{j=1}^{k} [\beta_j I_{it} x_{it,j} + \beta_j^{'} (1 - I_{it}) x_{it,j}]\} \right) \times$$
$$\gamma_t^{\delta_1 I_{it} + \delta_2 (1-I_{it})} s_{it-1}^{1-\delta_1 I_{it} - \delta_2 (1-I_{it})} + \varepsilon_{it}, \tag{28}$$

which is the estimating equation. Applying NLLS to Equation (28), as in Section 4.4.1, and using (for consistency with the previous section) the series LSLIBOR for the spread, I obtain the results of Table 4.6.

Table 4.6 Nonlinear regression with partial adjustment & fixed country-specific effects

DATA SET - 11 EUROZONE COUNTRIES

SPREAD SERIES: SPREAD OVER LIBOR (LIBOR) – Threshold: Rating based

NLLS, Convergence in 8 Iterations, Durbin-Watson Statistic = 2.26

	Variable	Coefficient		T-Stat
1	DUMMY	-6.315	***	-9.300
2	DINFL	43.632	***	4.058
3	DGDPGRO	-10.076	***	-3.211
4	DUR	16.893	***	5.008
5	DPUBINV	-0.003		-1.274
6	DELTA1	0.675	***	5.285
7	D1	-5.355	***	-16.135
8	D1INFL	11.295		1.168
9	D1DEBTGDP	0.788	***	2.643
10	D1GDPGRO	-9.421		-1.476
11	D1PRIMBS	-9.543	*	-1.785
12	DELTA2	0.530	***	3.300

DATA SET - 32 OECD COUNTRIES

SPREAD SERIES: SPREAD OVER LIBOR (LIBOR) – Threshold: Rating based

NLLS, Convergence in 23 Iterations, Durbin-Watson Statistic = 2.01

	Variable	Coefficient		T-Stat
1	DUMMY	-4.281	***	-25.154
2	DINFL	6.871		1.358
3	DGDPGRO	-28.105	***	-7.228
4	DELTA1	0.374	***	9.002
5	D1	-6.715	***	-11.553
6	D1INFL	31.033	***	2.970
7	D1DEBTGDP	0.338		1.316
8	D1GDPGRO	-11.794	***	-3.488
9	D1PRIMBS	-5.217	***	-2.685
10	D1UR	4.031		1.181
11	DELTA2	0.662	***	6.136

*Notes: (1) The dashed line is for distinguishing the two regimes; (2) ***, **, and * indicate statistical significance at the 1-percent, 5-percent, and 10-percent level, respectively; (3) the p-values for the hypotheses that the coefficients of DPUBINV, D1GDPGRO are zero against two-sided alternatives are 0.202, 0.139, respectively; Likewise for the variables DINFL, D1DEBTGDP, in the second data set with p-values 0.174, 0.188, respectively. I retained also the variables D1UR, D1INFL, because their t-statistics are larger than one in absolute value.*

Again, the results justify the existence of a threshold value in both data sets. Convergence was achieved in 8 and 23 iterations, respectively. Strong evidence of diversification between the two states was noticed, while most of the variables were statistically significant after dropping the insignificant ones. In the first data set, I keep *DPUBINV*, *D1GDPGRO*, because they are significant at the 10-percent level assuming a one-sided alternative and *D1INFL,* although is not significant even at the 10-percent level, because the value of its *t*-statistic is greater than one, so, according to Haitovsky (1969), keeping it improves the fit, i.e., it increases the $\bar{R}^2$ of the regression. The significant variables for the high spread area, that are the same for both data sets, namely *DUMMY*, *DINFL*, *DGDPGRO*, and *DELTA1*. In the lower part, for the 11 Eurozone countries, I find that all the macroeconomic variables except *D1UR* are significant and none from the set of the quality-of-institutions variables, whereas for the 32 OECD countries, the variable *D1UR* was insignificant but with t-statistic larger than one. In each data set the coefficients differ noticeably from one regime to the other. For instance, the coefficient of Inflation in the high spread area regime for the EU data is 43.63 whereas in the low-spread regime it is only 11.3. The coefficients of partial adjustment are both highly significant and smaller than one. In the 11 Eurozone countries, they suggest that the adjustment occurs faster in the upper part and less fast in the lower part, indicating that government bond yield spreads are affected more quickly by information regarding government creditworthiness and financial health in the high-spread regime than in the low-spread regime. For completeness, I have also incorporated time effects. The results are fairly similar, except that the some coefficients became unstable in that their sizes and their statistical significance are somewhat different. I have also attempted to use GMM, but the results were not so encouraging for both data sets.

4.4.3 The log-linear model

The nonlinear model produced empirical results that support the hypothesis of a threshold in the spread function. It's set up, however, does not allow the estimation of a random-effects model, thus I only estimated a fixed-effects model, with no time effects. Therefore, in this Section I estimate a log-linear version of the model, which allows the estimation of a random-effects model. Furthermore, we are going to incorporate not only fixed country specific effects but also time effects in our analysis. Taking logarithms in Equation (20) yields

$$\log s_{it} - \log \gamma_t = \exp(\sum_{j=1}^{k} \beta_j x_{it,j}) \ , \tag{29}$$

Assuming fixed country-specific effects only, and allowing for two regimes, Equation (19) becomes

$$\log s_{it} - \log \gamma_t = \sum_{i=1}^{N-1} \theta_i D_i + \sum_{j=1}^{k} [\beta_j I_{it} x_{it,j} \ + \ \beta_j '(1 - I_{it}) x_{it,j}] + \varepsilon_{it} \ , \tag{30}$$

As a first step I estimated Equation (30) with a restriction imposed, i.e.. where the dependent variable is R_{it} = $\log s_{it} - \log \gamma_t$, $\log s_{it}$ = *LSLIBOR*= log(*LIBOR*), and the other variables are defined as before, by applying to both data sets the standard ordinary least squares dummy-variable (LSDV) method with robust standard errors. The original results were, with the mean of the 11 Eurozone countries as a threshold. Using the spread over Libor with the rating based threshold, the Ramsey's RESET, did not indicated mis-specification, but the Durbin-Wu-Hausman test, which tests the hypothesis that the LSDV estimator is consistent, rejected the null hypothesis.

Therefore, I continued without the imposed restriction, i.e., with the *log*γ_t, in the right hand side of the equation,

$$\log s_{it} = \sum_{i=1}^{N-1} \theta_i D_i + \sum_{j=1}^{k} [\beta_j I_{it} x_{it,j} \ + \ \beta_j '(1-I_{it}) x_{it,j}] + \alpha I_{it} \log \gamma_t + \alpha (1-I_{it}) \log \gamma_t + \varepsilon_{it} \ , \quad (30)'$$

I estimated the above equation with fixed country specific effects but no time effects. Again, as diagnostic tests, I have used Ramsey's RESET, to test for mis–specification, and the Durbin-Wu-Hausman test. The results are reported in Table 4.7

Table 4.7 Log-linear regression with fixed country-specific effects

SPREAD SERIES: SPREAD OVER LIBOR (LIBOR) – Threshold: Rating based

DATA SET - 11 EUROZONE COUNTRIES

NLLS, Convergence in 8 Iterations, Durbin-Watson Statistic = 1.968

	Variable	Coefficient		T-Stat
1	DINFL	17.512	***	3.877
2	DGDPGRO	-14.384	***	-6.863
3	DPRIMBS	-3.245	**	-1.989
4	DUR	11.378	***	5.164
6	D1INFL	11.276	*	1.847
7	D1DEBTGDP	1.237	***	3.414
8	D1GDPGRO	-4.821		-1.617
9	D1PRIMBS	-10.868	***	-3.238
10	D1RLAW	-0.388	**	-2.126

DATA SET - 32 OECD COUNTRIES

NLLS, Convergence in 23 Iterations, Durbin-Watson Statistic = 1.474

	Variable	Coefficient		T-Stat
1	DLGAMMA	-3.697		-1.128
2	DDEBTGDP	-0.254	*	-1.864
3	DGDPGRO	-8.894	***	-4.728
4	DUR	6.397	***	6.149
5	DGOVEFFECT	-0.515	***	-3.904
6	DPUBINV	-0.006	***	-4.483
7	D1GDPGRO	-6.851	***	-3.139
8	D1PRIMBS	-4.867	***	-2.687
9	D1GOVEFFECT	-0.834	***	-6.791
10	D1PUBINV	-0.004	***	-3.620

*Notes: (1) The dashed line is for distinguishing the two regimes. (2) The superscripts ***, **, and * indicate statistical significance at the 1-percent, 5-percent, and 10-percent level, respectively. The p-values for the hypotheses that the coefficient of D1GDPGRO in the first data set is zero against two-sided alternatives is 0.10 respectively. I retained also the variables DLGAMMA for the second data, because the t-statistic is larger than one in absolute value.*

The results for the first data set are promising. I have chosen to keep the all the variables with absolute value of its *t*-statistic is greater than one. In the high-spread regime the variables *DGDPGRO* and *DUR* are common for both data sets, whereas the variables *D1GDPGRO, D1PRIMBS* were common in the low spread-regime for both data sets. It is noteworthy that from the set of the quality-of-institution variables the *D1RLAW* was found statistically significant for the first data set, and the *DGOVEFFECT and D1GOVEFFECT* for the second data set. Furthermore, the null hypothesis of correct specification is not rejected, since the RESET, with the second and third power of the fitted values as additional regressors, gives F(2, 154) = 1.054

(p-value = 0.34). The Durbin-Wu-Hausman test rejects (p-value = 0.004), however, perhaps because of the absence of time effects, which are therefore included in the error term and are likely to be correlated with some of the explanatory variables, such as the debt-to-GDP ratio. The set of instruments used for this test was $\mathbf{V}_1$= (dum(1), dum(2), dum(3), dum(4) dum(5), dum(6), dum(7), dum(8), dum(9), dum(10), DUMMY, DLGAMMA, DLGAMMA{1}, DINFL{1}, DDEBTGDP{1}, DGDPGRO{1}, DPRIMBS{1}, DUR{1}, DPUBINV{1}, DCORRU, DGOVEFFECT, DCORRU{1}, DGOVEFFECT{1}, DRLAW, DRLAW{1},DPOLSTAB, DPOLSTAB{1}, DREGQUALITY, DREGQUALITY{1}, DVACOUNT, DVACOUNT{1}, D1LGAMMA, D1LGAMMA{1}, D1INFL{1}, D1DEBTGDP{1}, D1GDPGRO{1}, D1PRIMBS{1}, D1UR{1}, D1PUBINV{1}, D1CORRU, D1GOVEFFECT, D1CORRU{1}, D1GOVEFFECT{1}, D1RLAW, D1RLAW{1}, D1POLSTAB, D1POLSTAB{1}, D1REGQUALITY, D1REGQUALITY{1}, D1VACOUNT, D1VACOUNT{1}). In an attempt to remedy this problem, in section 4.4.5 I will include time effects.

4.4.4 The log-linear model with partial adjustment and fixed country-specific effects

In the previous Section, there was evidence of misspecification when the second data set was used. In an effort to correct this problem, I use the partial adjustment model, for the log-linear specification, assuming fixed country-specific effects only. Thus, the estimating equation is

$$\log(s_{it}) = [\delta_1 I_{it} + \delta_2 (1 - I_{it})]\{\sum_{i=1}^{N-1} \theta_i D_i + \sum_{j=1}^{k} [\beta_j I_{it} x_{it,j} + \beta_j^{'} (1 - I_{it}) x_{it,j}]\}$$
$$+ [\delta_1 I_{it} + \delta_2 (1 - I_{it})] \log \gamma_t + [1 - \delta_1 I_{it} - \delta_2 (1 - I_{it})] \log(s_{it-1}) + \varepsilon_{it}. \qquad (31)$$

The results produced by applying various methods, including GMM, to Equation (21) were not so encouraging, however. For example, for both data sets, the estimates of δ_1 and δ_2 exceeded unity. Assuming only one "speed of adjustment" parameter did not improve the results, so this option was abandoned.

4.4.5 The log-linear model with both fixed country-specific and time effects

The model should also incorporate time effects. For example, the years from 2007 onward might have had a special impact on the spread, because of the financial crisis. Thus, If we assume fixed time effects, we simply add *T*-1 time dummies to the estimating equation (30), which now becomes,

$$\log s_{it} = \sum_{i=1}^{N-1} \theta_i D_i + \sum_{i=1}^{T-1} \tau_i DT_i + \sum_{j=1}^{k} [\beta_j I_{it} x_{it,j} \ + \ \beta_j '(1 - I_{it}) x_{it,j}] + \log \gamma_t + \varepsilon_{it} \ , \qquad (32)$$

I estimated the above equation using the spread over Libor with the rating based threshold for both data sets and again, as diagnostic tests, I have used Ramsey's RESET, and the Durbin-Wu-Hausman test. The results are reported in Table 4.8.

Table 4.8 Log-linear regression with fixed country-specific and time effects (EU)

DATA SET - 11 EUROZONE COUNTRIES

SPREAD SERIES: SPREAD OVER LIBOR (LIBOR) – Threshold: Rating based

OLS with Eicker-White Standard Errors - Durbin-Watson Statistic 1.816

	Variables	Coefficient	t-Statistic
1	DLGAMMA	-19.741 ***	-5.115
2	DINFL	10.808 ***	4.284
3	DGDPGRO	-6.143 ***	-5.978
4	DUR	10.275 ***	10.714
5	DPUBINV	-0.004 ***	-2.836
6	D1INFL	6.675 *	1.642
7	D1GDPGRO	-5.223 ***	-3.510
8	D1PRIMBS	-2.839 **	-2.110
9	D1UR	8.7014 ***	5.489
10	D1CORRU	-0.309 ***	-3.873
11	D1GOVEFFECT	-0.168	-1.498

*Notes: (1) The dashed line distinguishes the two regimes; (2) the superscripts ***, **, and * indicate statistical significance at the 1-percent, 5-percent, and 10-percent level, respectively; (3) RESET: Chi-Squared (2) = 0.02 (p-value = 0.99);*

The null hypothesis of correct specification is not rejected, since the *p*-value for the RESET with the second and third powers of the fitted values as additional regressors is 0.99. I also implemented the Durbin-Wu-Hausman test, which provided improved results (relative to those of section 4.4.3), but still rejects the null hypothesis at the 5 percent level (*p*-value=0.023). The instrument set used for this test is $\mathbf{V}_1$ in section 4.4.3 expanded to include time dummies. I then proceed to estimate equation (32) by the method of Instrumental Variables. Table 4.9 reports the results.

Table 4.9 Instrumental variables estimation with individual and time effects

Linear Regression - Estimation by Instrumental Variables

With Heteroscedasticity/Misspecification Adjusted Standard Errors (D.W. 2.21)

	Variable	Coefficient		t-Stat
28	DLGAMMA	-26.863	***	-5.800
29	DINFL	12.870	***	5.006
30	DGDPGRO	-6.674	***	-6.897
31	DUR	10.936	***	10.351
32	DPUBINV	-0.009	***	-3.822
33	D1GDPGRO	-2.003		-1.355
34	D1PRIMBS	-4.519	**	-2.512
35	D1UR	6.764	***	4.054
36	D1CORRU	-0.389	***	-3.884
37	D1GOVEFFECT	-0.175		-1.514

*Notes: (1) The dashed line is for distinguishing the two regimes. (2) The superscripts ***, **, and * indicate statistical significance at the 1-percent, 5-percent, and 10-percent level, respectively. The p-values for the hypotheses that the coefficients of D1GDPGRO, D1GOVEFFECT in the first data set are zero against two-sided alternatives are 0.175 and 0.130 respectively.*

The results of Table 4.9 are not substantially different from those of the LSDV method (see Table 4.8). Thus, the results produced by the log-linear model (Table 4.8) are not considered unreliable. In both Tables 4.8 and 4.9, the signs of the coefficient estimates are as expected: (1) positive for the inflation rate (the Fisher effect); (2) negative for the growth rate of real GDP, as higher growth improves the country's creditworthiness; (3) positive for the unemployment rate; (4) negative for the primary budget surplus, (5) negative for the public investment; and (6) negative for the quality-of-institutions indicators included in the regressions (control of corruption, and government effectiveness), as higher values of these variables indicate better quality of institutions.

The coefficients are statistically significant, except for the variable *D*1*GOVEFFECT*, which is significant only at the 10-percent level assuming a one-sided alternative. In addition, the existence of a threshold value is obvious. In both Tables 4.8 and 4.9, the high-spread regime contains five variables (*DLGAMMA*, *DINFL DGDPGRO*, *DUR* and *DPUBINV*), whereas the low-spread regime contains six variables in Table 4.8 (*D*1*INFL D*1*GDPGRO*, *D*1*PRIMBS*, *D*1*UR*, *D*1*CORRU* and *D*1*GOVEFFECT*) and five in Table 4.9 (the previous ones, but *D*1*INFL*). The coefficients of the variables that are common to the two regimes differ in size (but not in sign), indicating that the impact on the spread is different across the two regimes. Note that the coefficients are semi-elasticities. For example, in Table 4.8, a *ceteris-paribus* increase in the inflation rate by one percentage point, say, from 0.04 to 0.05, is expected to increase the spread by 10.81%, i.e., from 0.04 to 0.0443 in the high-spread regime, and by 6.68%, i.e., from 0.04 to 0.0427 in the low-spread regime.

Furthermore, the sizes of the coefficients are larger in the high-spread regime, a finding that is consistent with the hypothesis that a risk seeking decision maker has inelastic demand for loans and ends up paying a higher spread.

To further check the robustness of the results, I perform the same estimation in the second data set and report the results in Table 4.10, since GMM estimates can be sensitive to changes in the sample (Stock et al., 2002, p. 527).

Table 4.10 Log-linear regression with fixed country-specific and time effects(OECD)

DATA SET - 32 OECD COUNTRIES

SPREAD SERIES: SPREAD OVER LIBOR (LIBOR) – Threshold: Rating based

OLS with Eicker-White Standard Errors

Durbin-Watson Statistic 1.4180

	Variables	Coefficient		t-Statistic
1	DGDPGRO	-8.375	***	-4.568
2	DUR	5.494	***	5.204
3	DGOVEFFECT	-0.185	*	-1.681
4	DPOLSTAB	-0.277	***	-2.686
5	DPUBINV	-0.007	***	-4.826
6	D1GDPGRO	-3.723	**	-1.953
7	D1PRIMBS	-4.070	**	-2.446
8	D1UR	1.595		1.012
9	D1GOVEFFECT	-0.666	***	-7.276
10	D1PUBINV	-0.005	***	-3.796

*Notes: (1) The dashed line is for distinguishing the two regimes. (2) The superscripts ***, **, and * indicate statistical significance at the 1-percent, 5-percent, and 10-percent level, respectively. I kept the variables with t-statistic larger than one namely D1UR, with p-value 0.311, (see Haitovsky, 1969).*

Again, the coefficients are correctly signed and most of them are statistically significant, including the quality-of-institutions variables. The high-spread regime contains five variables (*DGDPGRO, DUR* and *DPUBINV,* which are present also in the first data set, together with *DGOVEFFECT* and *DPOLSTAB*), whereas the low-spread regime contains five variables (*D*1*INFL, D*1*GDPGRO, D*1*PRIMBS, D*1*UR,* and *D*1*GOVEFFECT,* which are common with the first data set together with *D1PUBINV*). Again, the coefficients of the variables that are common to the two regimes differ in size (but not in sign), indicating that the impact on the spread is different across the two regimes.

In addition, as previously, the sizes of the coefficients are larger (in absolute value) in the high-spread regime. For instance, the coefficient of the growth rate of real GDP is -8.375 in the high spread, whereas in the low spread regime is -3.723. The results from the OECD data set support the hypothesis that a risk seeking decision maker has inelastic demand for loans and ends up paying a higher spread.

4.4.6 The log-linear model with random country-specific and time effects

The analysis so far has modeled heterogeneity across countries by assuming fixed effects only. The differences between countries are treated strictly as parametric shifts of the regression function. This model applies only to the cross-sectional units included in the study, but not to the general population of similar countries (Greene, 2008, pp. 200-201). If the country-specific effects are treated as random variables that are uncorrelated with the regressors, then we can use the more general random-effects model, which has the additional advantage that it greatly reduces the number of parameters to be estimated.

To test the assumption that the country-specific random effects are uncorrelated with the regressors, I use the standard Hausman (1978) test. If it rejects, then the fixed-effects model is more appropriate. The Hausman (1978) test is based on the idea that under the hypothesis of no correlation, both OLS in the LSDV model and GLS (in the random-effects model) are consistent, but OLS is inefficient, whereas under the alternative, OLS is consistent, but GLS is not. Therefore, under the null hypothesis, OLS and GLS estimates should not differ systematically, and the test is based on the difference between the two, while the covariance matrix of the difference of the coefficients vector is taken into account.

The model should also incorporate time effects. Equation (19), is made stochastic by adding an error term, ε_t. In the case of the random-effects model, the precise definition of ε_t is important, since it can account for heterogeneity among countries as well as for possible time effects.

If we assume fixed time effects, we simply add *T*-1 time dummies to the estimating equation. If, on the other hand, we assume random effects, then the error term has the form

$$u_{it} = \varepsilon_i + \lambda_t + \eta_{it}, \tag{33}$$

where ε_i is the individual (country-specific) effect, λ_t is the time effect, and η_{it} is a general error to the equation. The model is estimated by GLS, as implemented by the routine PREGRESS of WinRATS 9.0. In the original version of the thesis, I used the *LMINSPREAD* series with the mean spread of the EU countries as a benchmark. The results, reported in Appendix A.5, were consistent with the main findings of this study and the Hausmann test did not reject the random individual and time effects. In this section, I use the *LSLIBOR* series for the spread with the rating based threshold.

Using both data sets, I estimated equation (30) assuming random country-specific and time effects. I have applied various algorithms that give consistent estimators of the variances of the random components, namely the Wansbeek-Kapteyn, the Swamy-Arora, the Wallace-Hussain, and the maximum likelihood, but only the one from Wooldridge (2010) provided some estimates. The results were generally unstable, and the Hausman test rejected the random-effects model in all cases. For completeness, however, I present the results in Table 4.11 and 4.12 for the first data set. In the light of the Haussmann test, the random effects approach is not the appropriate one using the rating based threshold.

Table 4.11 Log-linear regression results with random effects (individual effects)

SPREAD SERIES: SPREAD OVER LIBOR (LIBOR) – Threshold: Rating based

DATA SET - 11 EUROZONE COUNTRIES

Hausman Test(10) 64.47, Significance Level 0.0

	Variable	Coefficient		t-Stat
1	DUMMY	-4.604	***	-10.548
2	DINFL	14.508	***	2.769
3	DGDPGRO	-13.020	***	-5.035
4	DPRIMBS	-2.772	*	-1.711
5	DUR	10.451	***	5.320
6	DGOVEFFECT	-0.391	**	-1.966
7	D1GDPGRO	-7.226	*	-1.856
8	D1PRIMBS	-13.165	***	-3.361
9	D1UR	-15.382	***	-4.469
10	D1GOVEFFECT	-1.972	***	-13.240

*Notes: (1)The dashed line is for distinguishing the two regimes. (2) the DDEBTGDP, with routine WHITE, becomes significant in 1-percent level. (3) The superscripts ***, **, and * indicate statistical significance at the 1-percent, 5-percent, and 10-percent level, respectively*

Table 4.12 Log-linear regression results with random effects (time & individual)

SPREAD SERIES: SPREAD OVERLIBOR (LIBOR) – Threshold: Rating
DATA SET - 11 EUROZONE COUNTRIES
Log Likelihood -67.156
S.D. (eta_it) 0.401, S.D. (mu_i) 0.219 S.D. (lambda_t) 0.226

	Variable	Coefficient		t-Stat
1	DUMMY	-3.436	***	-10.390
2	DINFL	7.076	*	1.768
3	DGDPGRO	-2.699		-1.364
4	DUR	7.308	***	4.699
5	DGOVEFFECT	-0.220		-1.474
6	D1LGAMMA	-14.055	*	-1.817
7	D1DEBTGDP	-1.880	***	-6.280
8	D1PRIMBS	-6.555	**	-2.205
9	D1CORRU	-0.427	*	-1.818
10	D1GOVEFFECT	-0.465		-1.437

*Notes: (1)The dashed line is for distinguishing the two regimes. (2) the DDEBTGDP, with routine WHITE, becomes significant in 1-percent level. (3) The superscripts ***, **, and * indicate statistical significance at the 1-percent, 5-percent, and 10-percent level, respectively. I kept the variables with t-statistic larger than one namely DGDPGRO, DGOVEFFECT and D1GOVEFFECT,.*

4.4.7 Summary of the best empirical results

Most of the results presented in the previous sections suggest that there exists a reference point (a threshold) and that the spread function is regime-dependent. Both in the nonlinear and the log-linear model, the existence of a threshold is supported by the variation in the coefficients of the explanatory variables from regime to regime. For the 11-Eurozone countries, on which I focus in the present study, I obtained supportive empirical results from the nonlinear model with partial adjustment (section 4.4.2 Table 4.6) and from the log-linear model when assuming both fixed individual and time effects (section 4.4.6 Table 4.8). For convenience, I present again the best results in Table 4.13.

Table 4.13 Final results for the 11 Eurozone countries

Nonlinear regression results with partial adjustment & fixed country-specific effects

	Variable	Coefficient	t-Stat
1	DUMMY	-6.315 ***	-9.300
2	DINFL	43.632 ***	4.058
3	DGDPGRO	-10.076 ***	-3.211
4	DUR	16.893 ***	5.008
5	DPUBINV	-0.003	-1.274
6	DELTA1	0.675 ***	5.285
7	D1	-5.355 ***	-16.135
8	D1INFL	11.295	1.168
9	D1DEBTGDP	0.788 ***	2.643
10	D1GDPGRO	-9.421	-1.476
11	D1PRIMBS	-9.543 *	-1.785
12	DELTA2	0.530 ***	3.300

Log-linear with fixed country-specific and time effects

	Variables	Coefficient	t-Statistic
1	DLGAMMA	-19.741 ***	-5.115
2	DINFL	10.808 ***	4.284
3	DGDPGRO	-6.143 ***	-5.978
4	DUR	10.275 ***	10.714
5	DPUBINV	-0.004 ***	-2.836
6	D1INFL	6.675 *	1.642
7	D1GDPGRO	-5.223 ***	-3.510
8	D1PRIMBS	-2.839 **	-2.110
9	D1UR	8.7014 ***	5.489
10	D1CORRU	-0.309 ***	-3.873
11	D1GOVEFFECT	-0.168	-1.498

*Notes: (1) The dashed line distinguishes the two regimes; (2) the superscripts ***, **, and * indicate statistical significance at the 1-percent, 5-percent, and 10-percent level, respectively; All variables with t-statistic larger than one were kept according to the corresponding Tables 4.6 and 4.8.*

In the nonlinear model, the constant term (the coefficient of *DUMMY* and of *D*1 = 1 - *DUMMY*) is significant and differs little from regime to regime. Note that in the log-linear model this variable is statistically insignificant.

The inflation rate has been included in the regressions because it can be regarded as a qualitative measure of a countries macroeconomic health. As presented in Chapter 2, the sign of its coefficient appears to be a controversial issue in the literature. In the present study, however, in all of the estimated models, it has a positive sign in both regimes, meaning that a rise in the rate of inflation triggers a rise in the spread, which seems natural. The most noticeable difference is the impact of inflation on the spread dynamics. Consider the estimates from the log-linear model. The coefficients of the rate of inflation are 10.81 in the state of high spreads and 6.68 in the state of low spreads. Because these are semi-elasticities, their interpretation is as follows: a *ceteris-paribus* increase in the rate of inflation by one percentage point, say from 4 to 5 percent, is expected to increase the spread by 10.81%, that is from 5 to 5.545 in the state of high spreads, and from 5 to 5.334 that is by 6,890% in the state of low spreads. For the incumbent politician, this implies that when the spread is higher than the acceptable level, borrowing is extremely expensive. Furthermore, as we have commented in section 3.6, the demand for loans is less elastic for the risk seeker, therefore, in an increase in the demand for funds by the same amount, the risk lover will be charged a higher interest than the risk averse. With this in mind, if we observe a politician borrowing under these circumstances from the markets, we may assert that he exhibits risk-seeking behavior. Note, however, that in the nonlinear model the difference in the coefficients of inflation between the two regimes, 43.63 and 11.3, is higher than the difference in the coefficients in the log-linear model, 10.80 and 6.68, perhaps because the nonlinear model does not include time effects.

Next, consider the debt-to-GDP ratio. Contrary to what was expected, this variable, whose role is crucial in international markets, is not statistically significant in any of the high-spread regime in any of the two models. In the low-spread regime it appears statistically significant only in the nonlinear model. The same result was obtained in the original version of the thesis, where average spread was used as a threshold. The sign of its coefficient is positive, as expected, i.e., an increase in the indebtedness of a country leads to higher spreads.

Now consider the rate of growth of real GDP. It is significant in both regimes in both models. The sign of its coefficient is negative, as expected, implying that a higher growth rate would decrease the government bond yield and thus the spread.

Once again, the coefficients are higher (in absolute value) in the high-spread regime, as in the first version of the thesis.

The results for the primary surplus raise questions regarding the role of fiscal policy in the spread dynamics. This variable is significant in both models only in the low-spread regime. This is a noticeable variation between the two regimes, and suggests that fiscal policy affects the government bond spread only during tranquil periods. In other words, when spreads are low, a deterioration in the primary surplus would lead to an increase of the spread. On the other hand, when spreads are high, a deterioration in the primary surplus does not affect the spread. Taken on its face value, this result implies that the insistence on achieving primary surpluses in countries that suffer from high spread yields seems unreasonable. The case of the Greek rescue program seems to be consistent with this result. The majority of papers related to the determinants of long-term bond yields find that higher fiscal deficits and public debt raise interest rates. Gale and Orszag (2003) report that out of 59 studies, 29 find that fiscal deficits raise interest rates, 11 report mixed results, and 19 find that the effect is not significant. However, no study distinguishes the effect of the fiscal deficit on the spread depending on the level of the spread.

The rate of unemployment rate is significant in both models in the high-spread regime and only in the log-linear model itis significant in the low-spread regime. The sign of its coefficient is as expected in both models. This variable is not usually present in the literature, but it is significant in the present study. In the log-linear model, its coefficients are larger in the high-spread regime, suggesting that in the high spread regime the effect on the spread is higher. This implies that during periods of high unemployment rate the country's economy is considered weaker and the markets require an additional premium to compensate for their risk exposure. This forms a direct implication for the decision makers' preferences. If the incumbent politician decides to borrow when spreads are above the "fair" value, in order to fight the higher unemployment, knowing that this additional demand for funds would increase the spread by a lot, then this is an indication of risk-seeking behavior.

The *LGAMMA* variable is significant and well signed only in the log-linear model in the high-spread regime. Note that the coefficient of this variable is elasticity, since both the left-hand side variable and this explanatory variable are in logarithms. In the high spread area, a *ceteris-paribus* 1-percent increase in *GAMMA* would decrease the spread by almost 19,74 percent. *LGAMMA* contains the global risk free rate, thus when this rate rises, markets might lower their spread assessments in the same period. It appears that this effect is present only during periods of high spreads.

The coefficient of public investment is correctly signed and highly significant in the log-linear model in the high-spread regime, whereas in the nonlinear model it is retained because its t-statistic is larger than unity in absolute value, also in the high-spread regime. The negative sign of this coefficient implies that an increase in public investment of a country would lead to lower spreads, as expected.

Next, from the set of quality-of-institutions variables, only two were found to be significant. In particular, only in the log-linear model in the low-spread regime, the variable control of corruption is significant at the 1-percent level, whereas the variable government effectiveness is significant only in the 10-percent level assuming a one-sided alternative.[8]

The "speed of adjustment" coefficients δ_1 and δ_2 in the nonlinear model deserve also our attention. These coefficients are significant, lower than unity, and clearly different from regime to regime. The results indicate that the adjustment is faster in the high-spread than in the lower-spread regime. This suggests that government bond yield spread are affected by information regarding government creditworthiness and financial health more quickly and adjust faster when the spreads are high than when they are low. This implies that when a government faces high (low) spread pricing, an improvement in the key macroeconomic determinants would have a quick (not so quick) effect on the spread, and we expect the spreads to move faster (not so fast) towards the desired level.

Once again, the results remain fairly robust when I apply the same estimation to the larger data set (the 32 OECD countries), and also when I used the average spread of the 11 Eurozone countries as a threshold. The two-regime hypothesis still holds, the coefficients are in all cases correctly signed and differ from regime to regime. Furthermore, in every estimation the coefficients are larger in the high-spread regime, which is consistent with the assumption that a risk seeking decision maker has inelastic demand for loans and ends up paying a higher spread.

[8] In the original version I do not include any of these variables.

CHAPTER 5: CONCLUSION

The main purpose of this study has been to test the hypothesis that the effects of a set of explanatory variables, mainly macroeconomic, on the spread are larger when the spreads are high than when they are low. My empirical results support this hypothesis and remain robust to the following changes: (i) drastic change in the number of countries in the panel; (ii) different functional forms; (iii) different definitions of the benchmark; (iv) different definitions of the threshold; and (v) different estimation methods.

I consider a policy maker who considers borrowing, given the macroeconomic and institutional conditions of his/her country. The central question has been, Does there exist a reference point or "fair" spread that separates the policy maker's preferences from being risk averse to being risk seeking? In other words, is it realistic to assume that the standard models of spread determination are stable regardless of what macroeconomic and institutional conditions are prevailing?

The empirical evidence reported in Chapter 4 suggests that a threshold value does exist in the spread function, which therefore has two parts or regimes. One is referred to as the low-spread regime, in which the spread is lower than or equal to the "fair" spread, and the other as the high-spread regime, in which the spread is higher than the "fair" spread. I argue that the policy maker's behavior toward risk differs in these two regimes and, as a result, the effects of the macroeconomic and the institutional variables on the spread differ in the two regimes. Consider, for example, the effect of the rate of unemployment on the spread. When the rate of unemployment rises, the policy maker has an incentive to borrow funds from the markets and implement expansionary fiscal policy in order to fight unemployment, i.e., his/her demand for loans increases. Assuming that the demand for loans with respect to the rate of interest is inelastic for risk-seeking and elastic for risk-averse borrowers, the increase in the demand for loans will lead to a higher spread if the borrower behaves as a risk lover than if he/she behaves as a risk averter (see Figure 5).

Following prospect theory, I have presented a policy maker whose preferences depend on the spread, which in turn depends on a set of macroeconomic and institutional variables. I assume an *S*-shaped sub-utility function for the policy maker, which changes shape relative to a reference point, the "fair" value of the spread. In particular, if the spread is high, implying that his/her country's macroeconomic and institutional conditions cannot be relied upon to service the debt, the policy maker is losing, so a possible borrowing from the markets could be regarded as a risk-seeking choice, and thus his/her preferences are convex. On the other hand, if the spread is below or equal to the "fair" value, implying that his/her country's macroeconomic and institutional conditions are promising, he/she is winning, and an expansionary borrowing strategy appears to be a safe option, consistent with risk-averse preferences.

An important issue in my empirical analysis is the selection of the risk-free interest rate. This issue appears to be trivial in other studies, but is important in the present study, as the risk-free rate is supposed to reflect shocks to the global economy. I decided to choose the long-run interest rate of Germany as the risk-free rate, because it appeared the most stable one in the period that we are researching.

Another issue, which also appears to be trivial in the literature, was the selection of a suitable benchmark, the "most" risk-free asset, which forms the basis for the computation of the government bond spread. Note that even the most widely used benchmarks fluctuate greatly. As a proxy for this variable, I have constructed the variable MINRFB by taking the minima of the most widely used ones. The results reported in the text are based on the Libor over Euro benchmark, whereas those reported in Appendices A4 and A5 are based on MINRFB.

A more important issue is the empirical definition of the threshold. I have used several definitions, e.g., the average spread of the associated rating class that each country belongs to, the average spread of the government bond of the 11 EU countries, and the associated weighted average. The results reported in the text are based on the average spread of the associated rating class, whereas those reported in Appendices A4 and A5 are based on the other definitions.

I estimate nonlinear as well as log-linear versions of the model using both fixed country specific and time effects. I use two panel data sets, one consisting of 11 Eurozone countries, and the other consisting of 32 OECD countries, of which the 11 Eurozone countries of the first panel is a subset. Broadly speaking, the conclusions reached when the panel of the 11 Eurozone countries was used remain valid when the panel is enlarged by adding another 21 countries. This result strengthens the reliability of my empirical findings, which are as follows.

First, the results obtained from the nonlinear model with the partial-adjustment mechanism and fixed country-specific effects (but no time effects) and, are close with the ones obtained from the log-linear model with country specific and time effects.

Second, government bond pricing, as reflected in the spread over the risk-free benchmark, is regime-dependent, as (i) the estimated coefficients of the same variables that are statistically significant in both regimes differ substantially in size, but not in sign, namely, they are larger in absolute value in the high-spread regime, and (ii) the subsets of explanatory variables that are statistically significant differ from regime to regime. For instance, the inflation rate, the rate of growth of real GDP, and the rate of unemployment are statistically significant in both regimes in all estimations, whereas the primary surplus is significant only in the low-spread regime. Also, in most estimations, the debt-to-GDP ratio was insignificant, except in the nonlinear model in the low-spread regime. The "speed of adjustment" coefficients also differ from one regime to the other, and suggest that adjustment occurs faster in the high-spread regime than in the low-spread regime, which implies that in this case government bond yield spreads are more strongly affected by information related to the country's specific macroeconomic and institutional variables.

Third, surprisingly, in all estimations, the primary surplus and the debt-to-GDP ratio, on which many well-known financial institutions focus their attention, are not statistically significant in the high-spread regime. Taken at face value, this finding means that, for countries that suffer from high spreads, the evidence does not support the insistence on achieving primary surpluses and reducing the debt-to-GDP ratio, apparently because pursuing such targets will further deteriorate the economy and increase the probability of default. In the light of the above, the proposed policies applied to Greece, where the spreads are higher than the threshold, need to be re-examined.

Fourth, the finding that the sizes of the coefficients are larger in the high-spread regime is consistent with the hypothesis that a risk seeking decision maker has inelastic demand for loans and ends up paying a higher spread. If the policy maker decides to borrow when spreads are above the "fair" value, knowing that this additional demand for funds would increase the spread by a lot, then this is an indication of risk-seeking behavior.

Suggestions for future work could be made in two directions. First, an alternative approach to the mathematical formulation of the problem could be attempted, e.g., by making the utility maximization problem dynamic, so that the estimating equations could be derived from the solution of the optimization problem.

Second, the benchmark rate has been inserted in the spread evaluation in an ad hoc manner. A Markov-switching model could be used to calculate endogenously the benchmark from the data. For panel data, this seems to be computationally difficult. Alternatively, a Markov-switching model could be applied to time-series for the spread of each country separately. Then, the data for the benchmark can be formed by using these time-series data for the assessed benchmark from each country, and the panel regressions presented in Chapter 4 could be re-estimated with the new data for the benchmark rate.

REFERENCES

Acharya, V., and Steffen, S. (2013), The greatest carry trade ever? Understanding Eurozone bank risks, *CEPR Discussion Paper 9432*.

Acharya, V., Drechsler, I., and Schnabl, I. (2013),A Pyrrhic victory? Bank bailouts and sovereign credit risk, *Journal of Finance* (forthcoming).

Afonso, A. (2003), Understanding the determinants of sovereign debt ratings: evidence for the two leading agencies, *Journal of Economics and Finance*, 27 (1), 56-74.

Afonso, A., Gomes, P. and Rother, P. (2007),What "hides" behind sovereign debt ratings? Working Paper Series 711, *European Central Bank.*

Aizenman, J, Hutchison, M. M. and Jinjarak,Y. (2011),What is the risk of European sovereign debt default? Fiscal space, CDS spread, and market pricing of risk, *NBER WP 17407*.

Akitoby, B., and Stratmann, T. (2006) "Fiscal Policy and Financial Markets", IMF Working Paper.

Alekseev D. A. (2000), Investigation of the parameters of the logistic function and their economic interpretation , *Cybernetics and Systems Analysis*. 36. No. 2.

Attinasi, M. G., Checherita, C. and Nickel, C. (2009), What explains the surge in euro area sovereign spreads during the financial crisis of 2007- 09?, *ECB Working Paper*.

Avramovic, D., et al. (1964), Economic Growth and Debt. Baltimore: *John Hopkins Press.*

Baldacci, E. , Gupta, S. and Mati, A. (2008), Is it (Still) Mostly Fiscal? Determinants of Sovereign Spreads in Emerging Markets, *IMF Working Paper*

Barr, D.G. and Pesaran B. (1997),An Assessment of the Relative Importance of Real interest Rates, Inflation, and Term Premium in Determining the Prices of Realand Nominal U.K. Bonds, *Review of Economics and Statistics*, 79, 362-66.

Barrios, S., Iversen, P., Lewandowska, M., Setzer, R.(2009), Determinants of intra-euro area government bond spreads during the financial crisis *Economic Papers 388*, European Commission Directorate General for Economic and Financial Affairs.

Bassat, B.A. and Gotlieb,D.(1992),Optimal International Reserves and Sovereign Risk*The Journal of International Economics*, 33, 345-362

Bissoondoyal - Bheenick, E. (2005), An analysis of the determinants of sovereign ratings. *Global Finance Journal*, 15 (3), 251-280.

Breitung, J.(2000), The Local Power of Some Unit Root Tests for Panel Data. In: Baltagi, B.H., Fomby, T.B. and Hill, R.C., eds. Nonstationary Panels, Panel Cointegration, and Dynamic Panels, Advances in Econometrics, Vol. 15. Emerald Group Publishing Limited, 161-77.

Cantor, R. and Packer, F. (1994), The Credit Rating Industry. *Federal Reserve Bank of New York Quarterly Review* 19, no. 2: 1-26.

———, (1995), Sovereign Credit Ratings. Federal Reserve Bank of New York *Current Issues in Economics and Finance* 1(3).

———, (1996),Determinants and impact of sovereign credit ratings, *Federal Reserve Bank of New York Economic Policy Review* 2, 37-53.

Alexander C. and Kaeck A. (2008), Regime dependent determinants of credit default swap spreads, *Journal of Banking & Finance*,32 (6), 1008-1021.

Cassou, S. Shadmani, H. Vázquez, J. (2016), Fiscal policy asymmetries and the sustainability of US government debt revisited, *Empirical Economics,* Springer-Verlag Berlin Heidelberg.

Cooke R. (1991), Experts in Uncertainty; Opinion and Subjective Probability in Science, *Oxford University Press;* New York Oxford.

Cooke, R. and Bedford, T. (2001), Probabilistic Risk Analysis: Foundations and Methods, *Cambridge University Press.*

Cox, D.R. (1970), The analysis of binary data, London: Methuen.

Di Tella, R. ; Mac Culloch, R. ; Oswald A. (2001), Preferences over Inflation and Unemployment: Evidence from Surveys of Happiness, *The American Economic Review*,91(1).

Eaton, J., and Gersovitz, M. (1981), Debt with Potential Repudiation: Theoretical andEmpirical Analysis, *Review of Economic Studies*, 74.

Eaton, J., Gersovitz, M., and Stiglitz, J.E. (1986), The Pure Theory of Country Risk, *National Bureau of Economic Research.* Working Paper Series, No. 1894.

Eaton, J. (1996), Sovereign Debt, Repudiation, and Credit Terms. *International Journal of Finance and Economics*, no. 1 (January): 25-36.

ECB Monthly Bulletin, 63 (2014), Euro area risk-free interest rates: Measurement Issues, Recent developments and Relevance to monetary policy

Edwards, S. (1984), LDC Foreign Borrowing and Default Risk: An Empirical Investigation, 1976-80, *American Economic Review*, 74(4), 726-734.

Edwards, S. (1986),Country risk, foreign borrowing, and the social discount rate in an open developing economy *Journal of International Money and Finance* Volume 5, Supplement 1, March 1986, S79-S96.

Eichengreen, B. Portes, R. (1989),After the Deluge: Default, Negotiation and Readjustment in the Interwar Years, in B. Eichengreen and P. Lindert (eds.), *The International Debt Crisis in Historical Perspective* , 12-47 MIT Press,

Enders W. (2014) , Textbook Applied Econometric Time Series, 4th Edition, *John Wiley & Sons.*

Favero, C., Pagano, M., and von Thadden, E.-L. (2010), How does liquidity affect government bond yields? *Journal of Financial and Quantitative Analysis*,45(01),

Feder, G. and Just, R. (1977a), A Study of Debt Servicing Capacity Applying Logit Analysis, *Journal of Development Economics*, 4, 25-38.

Feder, G. and Just, R. (1977b), An Analysis of Credit Terms in the Eurodollar Market, *European Economic Review*, 9, 221-43.

Friedman, M., & Savage, L. J. (1948), The utility analysis of choices involving risk. *Journal of Political Economy*, 4, 279–304.

Frank, C. and Cline W. (1971), Measurement of debt servicing capacity: An application of discriminant analysis, *Journal of International Economics* Volume 1, Issue 3, 327-344.

Gallant, R. (1987), Nonlinear Statistical Models ,*John Wiley & Sons.*

Gerlach, S., SchulzA. and Wolff G.B. (2010), Banking and sovereign risk in the euro area, *Deutsche Bundesbank Discussion Paper N*◦ 09/2010.

Greene, W.H. (2008), Econometric Analysis. 6th ed. New Jersey: *Pearson Prentice Hall.*

Hadri, K. (2000), Testing for Stationarity in Heterogeneous Panel Data. *Econometrics Journal*, 3(2), 148-61.

Hall, R.E.(1988), Intertemporal Substitution in Consumption. *Journal of Political Economy*. 96(2), 339-57.

Haitovsky,Y.A. (1969), Note on the Maximization of $\bar{R}^2$, *The American Statistician* 23, 20-21.

Hamilton, J. D. (1988), Rational Expectations Econometric Analysis of Changes in Regime, *Journal of Economic Dynamics and Control*, 12, 385-423.

Hamilton, J. D. (1989), A new Approach to the Economic Analysis of Time Series," *Econometrica*, 57(2), 357-384.

Hamilton, J. D. (1990), Analysis of Time Series Subject to Changes in Regime," *Journal of Econometrics,* 45, 39-70.

Hamilton, J. D. (1994), Time Series Analysis. Princeton University Press.

Hamilton, J. D. (1996), Specification Testing in Markov-switching Times Series Models, *Journal of Econometrics*, 70, 127-157.

Hamilton, J. D. (2005), What's Real About the Business Cycle ?*Federal Reserve Bank of St. Louis Review* 87, 435-452.

Hansen B. (2000), Sample Splitting and Threshold Estimation, *Econometrica*,. 68(3), 575-603

Haque, N.U. Kumar M., Mark N. and Mathieson D. (1996), The Economic Contents of Indicators of Developing Country Creditworthiness *IMF StaffPapers*, 43. no.4, 688-724

Harberger, A.C.(1980), Vignettes on the World Capital Market,*American Economic Review*, 70, May, 331-337

Harris, R.D.F. and Tzavalis, E. (1999), (1999), Inference for unit roots in dynamic panels where the time dimension is fixed ,*Journal of Econometrics*, 91, 201–226.

Hatzinikolaou, D. (2002), Statistics for Economists.

Hatzinikolaou, D., Ahking F. (1995), Government Spending and Consumer Attitudes toward Risk, Time Preference, and Intertemporal Substitution: An Econometric Analysis, *Southern Economic Journal* 61, 1117-1126.

Hatzinikolaou, D. (1999), Modelling Consumption: Permanent-Income or Rule-of-Thumb Behaviour?,*Economic Modelling* 16, 293-306.

Hausman, J.A. (1978), Specification Tests in Econometrics, *Econometrica*, 46(6), 1251-71.

Haugh, D., Ollivaud, P. and Turner, D.(2009), What Drives Sovereign Risk Premiums? An Analysis of Recent Evidence from the Euro Area,*OECD Economics Department Working Papers* 718.

Hull, J. and White, A. (2013), LIBOR vs. OIS: The Derivatives Discounting Dilemma, *Journal of Investment Management*, 11 (3), 14-27.

Im, K.S., Pesaran, M.H., and Shin, S. (2003), Testing for Unit Roots in Heterogeneous Panels. *Journal of Econometrics*, 115(1), 53-74.

Kahneman, D. and Tversky, A. (1979), 'Prospect Theory: An Analysis of Decision under Risk',*Econometrica*, 47 (2), 263–291.

Kahneman, D. and Tversky, A. (1991), A. Loss Aversion in Riskless Choice: A Reference-Dependent Model, *The Quarterly Journal of Economics*, 106(4),1039-61.

Kahneman, D. and Tversky, A.(1992), Advances in Prospect Theory: Cumulative Representation of Uncertainty, *Journal of Risk and Uncertainty* 5, 297–323.

Keynes, J.M. (1936). *The general theory of employment, interest and money*. London: Macmillan.

Kmenta, J.(1971), Elements of Econometrics, *New York Macmillan Publishing Co.*

Knight, F.H.(1921), Risk, Uncertainty, and Profit, Harper & Row, Publishers, N.Y.

Kydland, F. Prescott, E. (1977), Rules Rather than Discretion: The Inconsistency of Optimal Plans, *The Journal of Political Economy,* 85(3), 473-492.

——— (1982), Time to Build and Aggregate Fluctuations,",*Econometrica* 50, 1345-1370.

Kuznar, L.A. (2002), Evolutionary applications of risk sensitivity models to socially stratified species Comparison of sigmoid, concave, and linear functions, *Evolution and Human Behavior* 23 (2002) 265–280.

Kuznar, L.A. & Lutz, J. M. (2007), Risk Sensitivity and Terrorism, *Political Studies*: 55, 341–361.

Levin, A., Lin, C-F., and Chu, C-S.J.(2002), Unit Root Tests in Panel Data: Asymptotic and Finite-sample Properties. *Journal of Econometrics*,108(1),1-24.

Maddala, G.S. and Wu, S. (1999), A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test. *Oxford Bulletin of Economics and Statistics*, 61(1), 631-52.

Markovitz, H. (1952), the Utility of Wealth, *The Journal of Political Economy*, 60(2) (Apr., 1952), 151-158.

McDonald, D.(1982), Debt Capacity and Developing Country Borrowing, *IMF Staff Papers*, , 29, 603-46.

Min, H.G. (1998), Determinants of Emerging Market Bond Spreads. Do Economic Fundamentals Matter? *World Bank Policy Research* Working Paper.

Montfort, A. and Renne J.P. (2011), Credit and liquidity risks in euro-area sovereign yield curves, *Document de travail n°352 Banque de France.*

Nath, H, (2009), Country Risk Analysis: A Survey of the Quantitative Methods. Economia Internazionale /*International Economics*, Vol. LXII, No. 1, 69-94.

Newey, W.K. and West, K.D. (1994), Automatic Lag Selection in Covariance Matrix Estimation. *Review of Economic Studies*, 61(4), 631-53.

Özdemir, A. (2004), Optimal International Reserves Behavior for Turkey, *The Central Bank of the Republic of Turkey.*

Ozler, Sule. (1991), Evolution of Credit Terms: An Empirical Examination of

Commercial Bank Lending to Developing Countries. *Journal of development Economics* 38: 79-97.

Olivier J. and Masson P. (2000), Currency Crises, Sunspots, and Markov-Switching Regimes, *Journal of International Economics* 50, 327-350.

Pagan, A.R., and Sossounov K.R. (2003), A Simple Framework for Analyzing Bull and Bear Markets. *Journal of Applied Econometrics* 18, 23-46.

Pedroni, P. (2004), Panel Cointegration; Asymptotic and Finite Sample Properties of PooledTime series Tests, With an Application to the PPP Hypothesis, *Econometric Theory*, 20, 597-625.

Pedroni, P.(1999), Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors, *Oxford Bulletin of Economics and Statistics*, 61, 653-670.

Rabin, M. (2000), Risk Aversion and Expected-Utility Theory: A Calibration Theorem *Econometrica*, 68 (5), 1281-1292.

Reinhart, C., and Rogoff K. (2010), Growth in a Time of Debt, *American Economic Review:* Papers & Proceedings 100, 573-578.

Rosenblatt- Wisch R. (2007), Loss Aversion in Aggregate Macroeconomic Time Series, *Swiss National Bank* .

Romer D. (2006), Advanced Macroeconomics, 3rd edition McGraw-hill, Irwin, Boston.

Sachs, J. and Cohen, D. (1982) LDC Borrowing with Default Risk, Working Paper No. 925, *National Bureau of Economic Research.*

Sachs, J. (1983), Theoretical Issues in International Borrowing, *National Bureau of Economics Research*, Working Paper No. 1189.

———(1985), Debt and Macroeconomic Performance in Latin America and East

Asia, *Brooking papers on Economic Activities*, 2, 523-64.

Sargent, N.(1977), Economic Indicators and Country Risk Appraisal. *Federal Reserve Bank of San Francisco* Economic Review.

Shiller, R. J. (1993). *Macro Markets: Creating Institutions for Managing Society's Largest Economic Risks*. Clarendon Press.

Shiller, R. J. (2005). *Irrational Exuberance* (2nd ed.). Princeton University Press.

Sims, C. and ZhaT. (2006), Were There Regime Switches in US Monetary Policy? *American Economic Review*. 96, 54-81.

Skiba, K. (1978), Optimal Growth with a Convex-Concave Production Function, *Econometrica,* 46 (3), 527-539.

Stock J, Wright J., and Yogo M., (2002), A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments. *Journal of Business and Economic Statistics*. (20) :518 – 529.

Taffler, R. J. and Abassi, B. (1984), Country Risk: A Model for Predicting Debt Servicing Problems in Developing Countries, *Journal of the Royal Statistical Society*. Series A (General), 147 (4) (1984), 541-568.

van Norden, S., and Vigfusson R. (1996), Regime-Switching Models: A Guide to the Bank of Canada Gauss Procedures," Working Paper 96-3, *Bank of Canada*.

von Neumann, J., & Morgenstern, O. (1944), Theory of games and economic behavior. Princeton: *Princeton University Press.*

Wakker, P. (1989), Additive Representations of Preferences: A New Foundation of Decision Analysis, Dordrecht, The Netherlands: *Kluwer Academic Publishers*.

Wooldridge, J. (2010), Econometric Analysis of Cross Section and Panel Data, 2nd Edition. *Cambridge, Mass.: The MIT Press*.

Yongcheol Shin, Byungchul Yu, and Greenwood-Nimmo M. (2013), Modelling Asymmetric Cointegration and Dynamic Multipliers in a Nonlinear ARDL Framework Festschrift in Honor of P.Schmidt, W.C. Horrace and R.C. Sickles, eds., *Forthcoming.*

Appendix A.1 Table with previous studies

Reference	Data	Explanatory variables	Agencies	Methodology
Cantor and Packer (1996)	Cross-section, 1995, 45 Countries	Per capita GDP, GDP growth, Inflation, current account surplus, government budget surplus, debt-to-exports, economic development, default history	S&P Moody's	Linear transformation of the data. OLS estimation.
Monfort and Mulder (2000)	Panel, 1995-1999 (half-yearly), 20 emerging markets	Debt-to-GDP, debt-to-exports, debt service-to-exports, debt reschedule, reserves, current account surplus, real effective exchange rate, export growth, short-term debt share, terms of trade, inflation, growth of domestic credit, GDP growth, government budget surplus, investment-to-GDP ratio, per capita GDP, US treasury bill rate, Spread over T-bonds, regional dummies	S&P Moody's	Linear transformation of the data. Two specifications: static (OLS estimation of the pooled data) and dynamic (error correction specification including as regressor the previous rating and several variables in first differences)
Eliasson (2002)	Panel, 1990-1999, 38 emerging markets	Per capital GDP, GDP growth, inflation, debt-to-exports ratio, government budget surplus, short-term debt to foreign reserves ratio, export growth, interest rate spread	S&P	Linear transformation of the data. Static specification and both fixed and random effects estimation. Dynamic specification.
Hu, Kiesel and Perraudin (2002)	Unbalanced panel, 1981-1998, 12 to 92 countries	Debt service-to-exports ratio, debt-to-GNP ratio, reserves to debt, reserves to imports, GNP growth, inflation, default history, default in previous year, regional dummies, non-industrial countries dummy	S&P	Ordered probit on pooled data. Two scales: 1-8 and 1-14
Afonso (2003)	Cross-section, 2001, 81 countries	Per capita income, GDP growth, inflation, current account surplus, government budget surplus, debt-to-exports ratio, economic development, default history	S&P Moody's	Linear, logistic and exponential transformation of the data. OLS estimation.
Alexe et al. (2003)	Cross-section 1998, 68 countries	Per capita GDP, inflation, trade balance, export growth, reserves, government budget surplus, debt-to-GDP ratio, exchange rate, domestic credit-to-GDP ratio, government effectiveness, corruption index, political stability	S&P	Linear transformation and OLS estimation.
Canuto, Santos and Porto (2004)	Panel 1998-2002, 66 countries	Per capita GDP, GDP growth, inflation, government debt to receipts, government budget surplus, trade to GDP, debt-to-exports ratio, economic development, default history	S&P Moody's Fitch	Linear transformation. OLS, fixed effects and first differences estimation.
Borio and Packer (2004)	Panel 1996-2003, 52 countries	Per capita GDP, GDP growth, inflation, corruption perception index, political risk index, years since default, frequency of high inflation periods, government debt-to-GDP ratio, debt-to-exports ratio, others	S&P Moody's	Linear transformation of data. OLS regression of average credit rating including year dummies as regressors.
Bissoondoyal-Bheenick, Brooks and Yip (2005)	Cross-section 2001, 60 countries	GDP, inflation, foreign direct investment to GDP, current account to GDP, trade to GDP, real interest rate, mobile phones	S&P Moody's Fitch	Estimate a ordered probit with 9 categories
Bissoondoyal-Bheenick (2005)	Panel 1995-1999, 95 countries	Per capita GDP, inflation, govt financial balance to GDP, government debt-to-GDP ratio, real effective exchange rate, export to GDP, reserves, unemployment rate, unit labour cost, current account to GDP, debt-to-GDP ratio	S&P Moody's	Estimate an ordered probit using two scales 1-21 and 1-9 for each year individually.
Butler and Fauver (2006)	Cross-section 2004, 93 countries	Per capita income, debt-to-GDP ratio, inflation, underdevelopment index, legal environment index, legal origin dummies	Institutional Investor	OLS estimation.

Source, Afonso A., Gomes P., and Rother P., (2007).

Appendix A.2 Empirical connection of variables and ratings

	Agency	Aaa/AAA	Aa/AA	A/A	Baa/BBB	Ba/BB	B/B
MEDIANS							
Per capita income	Moody's	23.56	19.96	8.22	2.47	3.3	3.37
	S&P	23.56	18.4	5.77	1.62	3.01	2.61
GDP growth	Moody's	1.27	2.47	5.87	4.07	2.28	4.3
	S&P	1.52	2.33	6.49	5.07	2.31	2.84
Inflation	Moody's	2.86	2.29	4.56	13.73	32.44	13.23
	S&P	2.74	2.64	4.18	14.3	13.23	62.13
Fiscal balance	Moody's	-2.67	-2.28	-1.03	-3.5	-2.5	-1.75
	S&P	-2.29	-3.17	1.37	0.15	-3.5	-4.03
External balance	Moody's	0.9	2.1	-2.48	-2.1	-2.74	-3.35
	S&P	3.1	-0.73	-3.68	-2.1	-3.35	-1.05
Debt	Moody's	76.5	102.5	70.4	157.2	220.2	291.6
	S&P	76.5	97.2	61.7	157.2	189.7	231.6
Spread	Moody's	0.32	0.34	0.61	1.58	3.4	4.45
	S&P	0.29	0.4	0.59	1.14	2.58	3.68
FREQUENCIES							
Number rated	Moody's	9	13	9	9	6	3
	S&P	11	14	6	5	9	4
Indicator for economic development	Moody's	9	10	3	1	0	0
development	S&P	10	11	1	1	0	0
Indicator for default	Moody's	0	0	0	2	5	2
history	S&P	0	0	0	0	6	3

Sources for the data: Moody's; Standard and Poor's; World Bank; International Monetary Fund; Bloomberg L.P.; J.P. Morgan; Federal Reserve Bank of New York estimates.

Source, Cantor R. and Packer F. (1996).

Appendix A.3 Matrices with the threshold performance per country

ABOVE THE MEAN, 1 OTHERWISE 0

	AUSTRIA	BELGIUM	ITALY	IRELAND	FINLAND	FRANCE	GERMANY	GREECE	THE NETHERLANDS	PORTUGAL	SPAIN	UP	DOWN
1997	0	0	1	0	0	0	0	1	0	1	1	4	7
1998	0	0	0	0	0	0	0	1	0	0	0	1	10
1999	0	0	0	0	0	0	0	1	0	0	0	1	10
2000	1	1	1	0	0	0	0	1	0	1	0	5	6
2001	1	1	1	0	0	0	0	1	0	1	1	6	5
2002	1	0	1	1	1	0	0	1	0	1	1	7	4
2003	0	0	1	0	0	0	0	1	0	1	0	3	8
2004	1	0	1	0	0	0	0	1	0	1	0	4	7
2005	0	0	1	0	0	0	0	1	0	1	0	3	8
2006	0	0	1	0	0	0	0	1	0	1	0	3	8
2007	0	0	1	0	0	0	0	1	0	1	0	3	8
2008	0	0	1	1	0	0	0	1	0	1	0	4	7
2009	0	0	1	1	0	0	0	1	0	1	0	4	7
2010	0	0	0	1	0	0	0	1	0	1	0	3	8
2011	0	0	0	1	0	0	0	1	0	1	0	3	8
2012	0	0	0	1	0	0	0	1	0	1	1	4	7
2013	0	0	1	1	0	0	0	1	0	1	1	5	6
2014	0	0	1	0	0	0	0	1	0	1	1	4	7
Stats Per country	**4**	**2**	**13**	**7**	**1**	**0**	**0**	**18**	**0**	**16**	**6**	**3,72**	**7,28**

ABOVE THE WEIGHTED MEAN, 1 OTHERWISE 0

	AUSTRIA	BELGIUM	ITALY	IRELAND	FINLAND	FRANCE	GERMANY	GREECE	THE NETHERLANDS	PORTUGAL	SPAIN	UP	DOWN
1997	0	0	1	1	0	0	0	1	0	1	1	5	6
1998	0	0	1	0	1	0	0	1	0	1	1	5	6
1999	1	1	1	1	1	0	0	1	0	1	1	8	3
2000	1	1	1	1	1	0	0	1	0	1	1	8	3
2001	1	1	1	1	1	0	0	1	0	1	1	8	3
2002	1	0	1	1	1	0	0	1	0	1	1	7	4
2003	1	0	1	0	0	0	0	1	0	1	0	4	7
2004	1	0	1	0	0	0	0	1	0	1	0	4	7
2005	0	0	1	0	0	0	0	1	0	1	0	3	8
2006	0	0	1	0	0	0	0	1	0	1	0	3	8
2007	0	1	1	1	0	0	0	1	0	1	0	5	6
2008	1	1	1	1	0	0	0	1	0	1	1	7	4
2009	1	1	1	1	0	0	0	1	0	1	1	7	4
2010	0	0	1	1	0	0	0	1	0	1	1	5	6
2011	0	0	1	1	0	0	0	1	0	1	1	5	6
2012	0	0	1	1	0	0	0	1	0	1	1	5	6
2013	0	0	1	1	0	0	0	1	0	1	1	5	6
2014	0	0	1	1	0	0	0	1	0	1	1	5	6
Stats Per country	**8**	**6**	**18**	**13**	**5**	**0**	**0**	**18**	**0**	**18**	**13**	**5.5**	**5.5**

RATING BASED MEAN, 1 OTHERWISE 0

	AUSTRIA	BELGIUM	ITALY	IRELAND	FINLAND	FRANCE	GERMANY	GREECE	THE NETHERLANDS	PORTUGAL	SPAIN	UP	DOWN
1997	0	NA	1	1	1	0	0	1	0	0	1	5	5
1998	1	NA	1	1	1	0	0	1	0	1	0	6	4
1999	1	NA	0	1	1	0	0	1	0	1	0	5	5
2000	1	NA	0	1	1	0	0	1	0	1	0	5	5
2001	1	0	1	1	1	0	0	1	0	1	0	6	5
2002	1	0	1	1	1	0	0	1	0	0	1	6	5
2003	1	0	1	1	1	1	0	0	0	0	1	6	5
2004	1	0	1	0	1	1	0	1	1	0	1	7	4
2005	1	0	1	0	0	1	0	1	1	0	1	6	5
2006	1	1	1	1	0	1	0	1	0	0	0	6	5
2007	1	1	1	1	0	1	0	1	0	0	1	7	4
2008	1	1	1	1	1	0	0	1	0	0	1	7	4
2009	1	0	1	1	1	0	0	1	0	0	1	6	5
2010	1	0	0	1	0	1	0	1	0	1	1	6	5
2011	1	0	1	1	0	1	0	1	0	1	1	7	4
2012	1	1	1	1	0	1	0	1	1	1	1	9	2
2013	1	1	1	0	1	1	0	1	1	1	1	9	2
2014	1	1	1	0	1	1	0	1	1	1	0	8	3
Stats Per country	17	6	15	14	12	10	0	17	5	9	12	6.50	4.28

Appendix A.4 Initial results for the Nonlinear model

Nonlinear regression results for the 11 Eurozone countries

Spread Series: LIBOR
Nonlinear Least Squares - Estimation by Gauss-Newton
Convergence in 24 Iterations. Final criterion was 0.0000059 <= 0.0000100
With Clustered Standard Error Calculations

	Variables	Coefficient	t-Statistic
1	DUMMY	-5.815 ***	-19.353
2	DINFL	25.545 ***	3.673
3	DGDPGRO	-9.257 ***	-9.008
4	DUR	13.352 ***	9.645
5	D1	-4.669 ***	-51.819
6	D1PRIMBS	-12.547 ***	-8.470
7	D1UR	8.376 ***	6.385

Spread Series : MINSPREAD
Nonlinear Least Squares - Estimation by Gauss-Newton
Convergence in 18 Iterations. Final criterion was 0.0000072 <= 0.0000100
With Clustered Standard Error Calculations

	Variables	Coefficient	t-Statistic
1	DUMMY	-5.410 ***	-22.018
2	DINFL	23.011 ***	3.998
3	DGDPGRO	-9.523 ***	-11.480
4	DUR	11.902 ***	8.825
5	D1	-4.665 ***	-53.544
6	D1PRIMBS	-10.334 ***	-9.498
7	D1UR	8.936 ***	7.962

*Notes: (1) The dashed line is for distinguishing the two regimes. (2) The superscripts ***, **, and * indicate statistical significance at the 1-percent, 5-percent, and 10-percent level, respectively.*

Nonlinear regression results with partial adjustment

DATA SET 1 - 11 EUROZONE COUNTRIES SPREAD SERIES : MINSPREAD – threshold mean EU Nonlinear Least Squares - Estimation by Gauss-Newton /Convergence in 10 Iterations Durbin-WatsonStatistic : 1.917			
	Variables	Coefficient	t-Statistic
1	DDUMMY	-5.293 ***	-17.701
2	DINFL	27.739 ***	5.007
3	DGDPGRO	-11.885 ***	-5.644
4	DUR	11.893 ***	5.052
5	D1	-4.999 ***	-20.195
6	D1INFL	10.890 *	1.934
7	D1DEBTGDP	0.370	1.021
8	D1GDPGRO	-12.098 ***	-3.088
9	D1PRIMBS	-7.582 ***	-4.354
10	D1UR	9.039 ***	3.540
11	δ1	0.727 ***	9.790
12	δ2	0.604 ***	5.404

DATA SET 2 - 32 OECD COUNTRIES SPREAD SERIES : MINSPREAD- threshold mean EU Nonlinear Least Squares - Estimation by Gauss-Newton Convergence in 8 Iterations Durbin-WatsonStatistic : 1.924			
	Variables	Coefficient	t-Statistic
1	DDUMMY	-4.223 ***	-28.669
2	DINFL	10.734 ***	2.931
3	DGDPGRO	-17.227 ***	-5.473
4	DUR	2.073 **	2.252
5	D1	-4.458 ***	-43.829
6	D1GDPGRO	-14.778 ***	-4.427
7	D1PRIMBS	-1.823 *	-1.648
8	D1UR	3.768 ***	4.750
9	δ1	0.454 ***	15.337
10	δ2	0.490 ***	7.301

*Notes: (1) The dashed line is for distinguishing the two regimes. (2The superscripts ***, **, and * indicate statistical significance at the 1-percent, 5-percent, and 10-percent level, respectively. (4) the significance level of B9(D1DEBTGDP) is 0.30*

Appendix A.5 Initial results for the log-linear model with random country-specific and time effects

Log-linear regression results with random effects and lags

DATA SET 1 - 11 EUROZONE COUNTRIES
SPREAD SERIES : LMINSPREAD
PREGRESS Routine, with random individual & time effects

Hausman Test : 7.894
Significance Level : 0.245

	Variables	Coefficient	t-Statistic
1	DUMMY	-4.827 ***	-14.297
2	DLGAMMA	-42.969 ***	-7.460
3	DINFL	7.041 ***	3.863
4	DDEBTGDP	0.335	1.581
5	DGDPGRO	-6.086 ***	-3.838
6	DUR	5.901 ***	3.927
7	DLGAMMA{1}	-3.245	-1.415
8	DLGAMMA{2}	32.110 ***	8.855
---	---	---	---
9	D1	-4.883 ***	-29.341
10	D1LGAMMA	-33.153 ***	-8.468
11	D1GDPGRO	-4.587 **	-2.486
12	D1UR	5.322 ***	6.088
13	D1LGAMMA{1}	-2.755	-1.080
14	D1LGAMMA{2}	33.170 ***	9.970

*Notes: (1) The dashed line is for distinguishing the two regimes. (2) the DDEBTGDP, with routine WHITE, becomes significant in 1-percent level. (3) The superscripts ***, **, and * indicate statistical significance at the 1-percent, 5-percent, and 10-percent level, respectively. (4) the significance level of DDEBTGDP is 0.113, DLGAMMA{1} is 0.157, D1LGAMMA{1} is 0.280*

Log-linear regression results with random effects and lags for both data sets

SPREAD SERIES : LMINSPREAD Routine PREGRESS , with individual & time effects					
DATA SET 1 - 11 EUCOUNTRIES HAUSMAN TEST : 7.89 SIGNIFICANCE : 0.245				DATA SET 2 – 32 OECD COUNTRIES HAUSMAN TEST : 67.42 SIGNIFICANCE : 0.000	
	Variables	Coefficient	t-Statistic	Coefficient	t-Statistic
1	DUMMY	-4.827***	-14.297	-3.832***	-34.832
2	DLGAMMA	-42.969***	-7.46	-25.896***	-9.088
3	DINFL	7.041***	3.863	3.920***	2.711
4	DDEBTGDP	0.335	1.581	-0.038	-0.648
5	DGDPGRO	-6.086***	-3.838	-3.092***	-2.746
6	DUR	5.901***	3.927	4.177***	7.405
7	DLGAMMA{1}	-3.245	-1.415	-20.449***	-7.568
8	DLGAMMA{2}	32.11***	8.855	32.317***	11.453
9	D1	-4.883***	-29.341	-4.785***	-44.764
10	D1LGAMMA	-33.153***	-8.468	-13.489***	-4.864
11	D1GDPGRO	-4.587**	-2.486	-3.290***	-2.702
12	D1UR	5.322***	6.088	6.326***	6.756
13	D1LGAMMA{1}	-2.755	-1.08	-25.115***	-9.235
14	D1LGAMMA{2}	33.17***	9.97	30.084***	10.772

*Notes: (1) The dashed line is for distinguishing the two regimes and the different data sets. (2) The superscripts ***, **, and * indicate statistical significance at the 1-percent, 5-percent, and 10-percent level, respectively.*

Appendix A.6 Interpretation of the regression coefficients as semi-elasticities

Consider the following log-linear equation, where $LSPREAD_i$ = log($SPREAD_i$):

$$LSPREAD_i = \beta_0 + \beta_1 INFL_i + \text{other explanatory variables} + u_i. \quad (1)$$

For the coefficient β_1 we obtain,

$$\beta_1 = \partial(LSPREAD_i)/\partial(INFL_i) = (1/SPREAD_i)\times\partial(SPREAD_i)/\partial(INFL_i). \quad (2)$$

Using discrete changes (thus replacing ∂ with Δ), Eq. (2) can be written as

$$\beta_1 \approx (1/SPREAD_i)\times\Delta(SPREAD_i)/\Delta(INFL_i), \quad (3)$$

or, after rearranging and multipying by 100, so as to obtain the percentage change in the spread, i.e., $\%\Delta(SPREAD_i) = 100[\Delta(SPREAD_i)/(SPREAD_i)]$, Eq. (3) yields

$$\%\Delta(SPREAD_i) \approx 100\beta_1\times\Delta(INFL_i) \quad (4)$$

or

$$\%\Delta(SPREAD_i)/\Delta(INFL_i) \approx 100\beta_1. \quad (5)$$

The quantity $\%\Delta(SPREAD_i)/\Delta(INFL_i)$ is thesemielasticityof the spread with respect tp the inflation rate. As Eq. (5) shows, for Model (1), it is equal to $100\beta_1$. That is, $100\beta_1$ is the percentage change in the $SPREAD_i$ when the rate of inflation changes by 1-percentage point. For example, suppose that the estimate of β_1 obtained from Eq. (1) is 0.2792. This means that, if the other explanatory variables remain fixed and *INFL* rises by 1-percentage point, say from 4 to 5 percent, then the *SPREAD* is expected to rise by 27.92% (=100×0.2792), say from 5 to 6.396.