

ESSAYS ON SOVEREIGN CREDIT RISK AND
CREDIT DEFAULT SWAP SPREADS

Patrick Augustin





Dissertation for the Degree of Doctor of Philosophy, Ph.D.
Stockholm School of Economics

KEYWORDS: Arbitrage; Basis; Credit Default Swaps; Corporate Bonds; Credit Risk; Generalized Disappointment Aversion; Liquidity; Literature Review; Sovereign Risk; Term Structure.

Essays on Sovereign Credit Risk and Credit Default Swap Spreads

©SSE and Patrick Augustin, 2013

ISBN 978-91-7258-901-8 (printed)

ISBN 978-91-7258-902-5 (pdf)

FRONT COVER ILLUSTRATION:

©Shutterstock/Serggod, 2013

BACK COVER ILLUSTRATION:

©Roger Leiner, 2013

BACK COVER PHOTO:

Isabelle Mersch, 2010

PRINTED BY:

Ineko AB, Göteborg, 2013

Foreword

This volume is the result of a research project carried out at the Finance Department of the Stockholm School of Economics (SSE). This volume is submitted as a doctor's thesis at SSE. In keeping with the policies of SSE, the author has been entirely free to conduct and present his research in the manner of his choosing as an expression of his own ideas. SSE is grateful for the financial support provided by the Swedish Bank Research Foundation, the Jan Wallander and Tom Hedelius Foundation and the Luxembourg National Research Fund, which have made it possible to fulfill the project.

Göran Lindqvist

Director of Research
Economic Research Institute
Stockholm School of Economics

Clas Bergström

Professor and Head of Department
Centre for Research in Finance
Stockholm School of Economics

To my brother, Philippe.

Acknowledgements

Writing these words means that I have accomplished a long journey marked by a multitude of emotions, ranging from apocalyptic frustration to utopic euphoria. Being admitted to defend my PhD thesis mirrors being rewarded with a medal at the end of an ultra-marathon. Just like a marathon race could not be completed without the help of all the people preparing the racing track, reaching drinks and cheering along the road, the PhD could not be achieved without the continuous support of people, friends and family around me. My gratitude goes to all of you.

Special thanks go to my past and present fellow PhD colleagues, who all have contributed in one way or the other to get me to the end of this journey. In particular my own cohort has helped me through ups and downs over the last 5 years. Boxing our way together through problem sets and exams, jointly celebrating milestones in the PhD program and numerous research and non-research related discussions have created a lifetime bond. I am happy to have gone through this process with my comrades: Mustafa Yildirim, who didn't rest until he had hammered the basic principles of game theory into my brain; Johannes Breckenfelder, who still tries to teach me tango lessons; Hamid Boustanifar, who keeps reminding me that a positive attitude can change the perspective of life. Over the last five years, I cannot remember one single day seeing him without a smile on his face; Jan Schnitzler, my sports buddy and New York flat mate, who was always available to revive my spirit with a seamless joke. I would also like to thank my numerous office mates over the years, Anna Lindahl, Linus Siming, Jieying Li, Fatemeh Hosseini and Ricardo Lopez. My friends from the Economics departments at the Stockholm School of Economics and Stockholm University helped me to escape from the finance bubble, in particular Abel Schumann, Pamela Campa, Taneli Mäkinen, Elena Mattana, and especially my close Swedish friends Mathias Ekström and Johan Egebark. I should also not forget to mention the more senior PhD colleagues, who have provided much useful advice along the road: Linus Kaisajuntti, Sam Lee, Reimo Juks, Kristoffer Lindensjö, Alberto Crosta and Andreas Nilsson.

It is difficult for me to express in words how grateful I am for the support of my principal advisors Magnus Dahlquist and Roméo Tédongap, as well as additional committee member Paolo Sodini. Their guidance and mentoring throughout the program and in particular during the job market are priceless. They were available for advice despite my endless questions. Without their support, I would not be where I stand now. Especially Roméo Tédongap deserves credit for his never-ending patience in teaching me the consumption-based asset pricing machinery and the greek alphabet soup of disappointment averse preferences. He was available to talk to me on Skype during the middle of the night when I was in New York and didn't give up on me at times when I forgot the essentials of mathematics and statistics after long night shifts. He is not only a supervisor, but has over the years become a close friend and is the father of my godson Nathan.

I should not forget to mention the remaining part of the faculty and department members of the Stockholm School of Economics and Swedish House of Finance: Mariassunta Giannetti, who served as a supervisor at the early stage of the program; PhD coordinator Mike Burkart, who was always happy to teach me some basic facts in soccer, despite his (probable) frustration over my applied contract theory skills; Per Strömberg, whose unbeatable intuition has shaped my way of thinking about economic questions; Clas Bergström, who was always supportive as head of the department; Laurent Bach, who showed solidarity during night shifts and always demonstrated enthusiasm to drag me out for a drink; Michael Halling, Bige Kahraman, Peter Englund, Tomas Björk, Francesco Sangiorgi and Ulf von Lilienfeld-Toal, who generously helped in proofreading my job market paper and in coaching me for the job market; as well as Pehr Wissén, Anders Anderson, Cristina Cella, Ramin Baghai, Daniel Metzger and Christian Huse, who all have added their grain of salt to my doctoral education. Anki Helmer, Jenny Anderson and Hedvig Mattson were throughout helpful in easing the administrative burden. Anneli Sandbladh patiently dealt with all my departmental questions and provided unforgettable support during the application process of the academic job market.

In addition to the Stockholm faculty, I would also like to thank the faculty of the Finance department at the New York University, Leonard N. Stern School of Business, for their generous hospitality during my academic visit in 2011/2012. In particular Marti G. Subrahmanyam, whom I have started to work with during my visit, was always open for a research chat. Moreover, I am grateful that he accepted to serve as an academic reference during the job market. Finally, Stanley Zin and David Backus from the Economics department unconditionally accepted me to their Macroeconomics workshop. Being exposed to their way of thinking was a valuable learning process.

Finally, I am grateful for the hospitality and support of Oliver Randall, with whom I enjoyed discussing research and who has become a good friend during my visit.

Going through the PhD requires significant financial support to cover living costs, expenses for conference travel, as well as the purchase of research equipment and data sources. I am therefore heavily indebted to the Luxembourg National Research Fund, the Swedish Bank Research Foundation, the Jan Wallander and Tom Hedelius Foundation, the Nasdaq OMX Nordic Foundation, the Siamon Foundation, the Infina Foundation and the Stockholm School of Economics Research Board.

Last and most importantly, I want to thank my girl-friend and my family. Mari consistently reminded me that there are other important things in life beyond research. I am happy for her patience with me. My parents Paul and Sabine laid the foundations for my career in academia. They have raised and educated me to become the person who I am now. No matter what my decision, they trusted and backed my choices. Their unconditional support and love leaves me with a perpetual debt I will never be able to fully pay back. To end, I want to mention the loving support of my brother Philippe. He has always stood by my side and never let me down. Until this day, I don't understand how he could stand my ever-ending stories about the PhD program, research questions, academia or finance-related topics. He has always tried to cheer me up in bad times and gave me an additional energy boost in good times. I am eternally grateful to have him around. This thesis is dedicated to him.

Stockholm, 6th September 2013

Contents

| | |
|--|------|
| List of Tables | xvii |
| List of Figures | xix |
| Introduction | 1 |
| Paper 1. Sovereign Credit Default Swap Premia | 5 |
| 1. Introduction | 5 |
| 2. What Are Credit Default Swaps | 7 |
| 3. The Market for Sovereign Credit Default Swaps | 10 |
| 4. Statistical Facts about Sovereign CDS | 13 |
| 5. Determinants of Sovereign CDS Spreads | 14 |
| 6. Spillovers and Contagion | 22 |
| 7. Frictions and the CDS-Bond Relationship | 26 |
| 8. Trading in the Sovereign CDS Market | 34 |
| 9. Conclusion | 38 |
| Paper 2. Real Economic Shocks and Sovereign Credit Risk | 59 |
| 1. Introduction | 59 |
| 2. U.S. Consumption Risk and Sovereign CDS Spreads | 63 |
| 3. A Macroeconomic Model for Sovereign Credit Default Swaps | 70 |
| 4. Model Estimation | 77 |
| 5. Asset Pricing Implications and Discussion | 80 |
| 6. Conclusion | 85 |
| Appendix | 87 |
| Paper 3. The Term Structure of CDS Spreads and Sovereign Credit Risk | 111 |
| 1. Introduction | 111 |
| 2. A Preference-based Model for Credit Default Swaps | 116 |
| 3. Asset Pricing Implications | 127 |
| 4. Empirical Investigations | 135 |
| 5. Conclusion | 140 |
| Appendix | 141 |

| | |
|--|-----|
| Paper 4. Squeezed Everywhere - Disentangling Types of Liquidity and Testing Limits-to-Arbitrage | 163 |
| 1. Introduction | 163 |
| 2. The CDS-Bond Arbitrage | 167 |
| 3. Basis and Variables of Interest | 170 |
| 4. Data and Summary Statistics | 175 |
| 5. Empirical Application | 180 |
| 6. Testing Limits-to-Arbitrage | 190 |
| 7. Conclusion | 191 |
| Appendix | 193 |
| Bibliography | 223 |

List of Tables

| | | |
|------|--|-----|
| 1.1 | Credit Default Swaps: Notional Amount Outstanding ('000,000) | 40 |
| 1.2 | OTC Derivatives: Notional Amount Outstanding ('000,000,000) | 41 |
| 1.3 | Exposures of CDS: Notional Amount Outstanding ('000,000) | 42 |
| 1.4 | Sovereign CDS: Notional Amount Outstanding ('000,000) | 42 |
| 1.5 | Counterparties of Single-Name Sovereign Credit Default Swaps | 43 |
| 1.6 | Maturity Structure of Credit Default Swaps: Notional Amount Outstanding ('000,000) | 44 |
| 1.7 | Credit Default Swaps by Location of Counterparty | 45 |
| 1.8 | Summary Statistics | 46 |
| 1.9 | Slope of the CDS Spread Curve | 47 |
| 1.10 | Trade Information Warehouse Data - 1 | 48 |
| 1.11 | Trade Information Warehouse Data - 2 | 49 |
| 1.12 | Trade Information Warehouse Data - 3 | 50 |
| 1.13 | Trade Information Warehouse Data - 4 | 51 |
| 1.14 | Trade Information Warehouse Data - 5 | 52 |
| 1.15 | Trade Information Warehouse Data - 6 | 53 |
| 2.1 | Country List | 94 |
| 2.2 | Summary Statistics | 95 |
| 2.3 | Principal Component Analysis | 96 |
| 2.4 | Kalman Filter Estimates | 96 |
| 2.5 | Regression Analysis - Macroeconomic and Financial Risk | 97 |
| 2.6 | Regression Analysis - Macroeconomic and Financial Risk | 98 |
| 2.7 | Country Regressions - Macroeconomic Risk and Variance Risk Premium | 99 |
| 2.8 | Parameters of the Markov-Switching Model | 100 |
| 2.9 | Model Estimation - Preference and Default Parameters | 101 |

| | | |
|------|--|-----|
| 2.10 | Model-Implied and Observed Term Structure of CDS Spreads AAA-B: Downside Risk Aversion | 102 |
| 2.11 | Model-Implied Term Structure of Default Probabilities AAA-B | 103 |
| 2.12 | Model-Implied and Observed Term Structure of CDS Spreads AAA-B: No Downside Risk Aversion | 104 |
| 3.1 | Summary Statistics | 149 |
| 3.2 | Model Parameter Calibration | 150 |
| 3.3 | Calibration of Default Parameters and CDS Implications | 151 |
| 3.4 | Asset Pricing Implications: Expected Losses, Risk Premia and Cumulative Default Probabilities | 152 |
| 3.5 | Principal Component Analysis | 153 |
| 3.6 | Country Regressions - CDS | 154 |
| 3.7 | Local Ratios | 155 |
| C.1 | Negative Basis Trade | 197 |
| C.2 | Positive Basis Trade | 198 |
| C.3 | Determinants of the Basis | 204 |
| C.4 | List of Companies | 205 |
| 4.1 | Primary Government Securities Dealers | 208 |
| 4.2 | Number of Companies, Mean and Volatility by S&P Rating and Industry Category | 209 |
| 4.3 | Mean Basis by S&P Rating, Industry Group and Sub-Periods | 210 |
| 4.4 | Summary Statistics for the Basis and Regressors | 211 |
| 4.5 | Univariate Regressions - Asset Liquidity and Market Liquidity | 212 |
| 4.6 | Univariate Regressions - Funding Liquidity and Counterparty Risk | 213 |
| 4.7 | Multivariate Regressions - 1 | 214 |
| 4.8 | Multivariate Regressions - 2 | 215 |
| 4.9 | Difference-in-Difference Regressions | 216 |
| 4.10 | Limits to Arbitrage - Flight-to-Quality and Margin-based Asset Pricing | 217 |
| 4.11 | Limits to Arbitrage - Liquidity Commonalities | 218 |

List of Figures

| | | |
|-----|---|-----|
| 1.1 | The Slope of the Credit Spread Curve | 54 |
| 1.2 | Co-Movement of Sovereign CDS Spreads and Risk Aversion | 55 |
| 1.3 | Trade Information Warehouse Data - 1 | 56 |
| 1.4 | Trade Information Warehouse Data - 2 | 57 |
| 2.1 | U.S. Growth, NBER Recessions and Sovereign Crises | 105 |
| 2.2 | Principal Component Analysis - Factor Loadings | 106 |
| 2.3 | Expected Consumption Growth and Consumption Volatility vs. 5-year Mean CDS Spread | 107 |
| 2.4 | Reversal of the CDS Term Structure | 108 |
| 2.5 | Hazard Rate Analysis: Downside Risk Aversion | 109 |
| 2.6 | Term Structure Analysis: No Downside Risk Aversion | 110 |
| 3.1 | Expected Consumption Growth and Consumption Volatility | 156 |
| 3.2 | Model-implied 5-year CDS Spreads and Slope vs. DATA | 157 |
| 3.3 | Local CDS Spreads and Variance Decomposition | 158 |
| 3.4 | Time Variation in the Term Structure | 159 |
| 3.5 | Analyzing the CDS Term Structure | 160 |
| 3.6 | Principal Components | 161 |
| 3.7 | The Slope of the CDS Term Structure and Local Ratios | 162 |
| C.1 | The Basis Trade | 196 |
| C.2 | Determinants of the Basis | 203 |
| 4.1 | The Basis | 219 |
| 4.2 | Main Regressors | 220 |
| 4.3 | Control Variables | 221 |
| 4.4 | Mean CDS-Bond Basis by Subgroups | 222 |

Introduction

This doctoral thesis consists of four independent research papers, which I wrote during my time as a PhD student at the Department of Finance of the Stockholm School of Economics from September 2008 to June 2013. Part of this work was accomplished when I visited the Finance Department of the New York University, Leonard N. Stern School of Business, during the academic year 2011/2012.

All four papers are self-contained and written with the purpose of eventually being published as separate articles in academic journals. The first three articles share the common theme of sovereign credit risk as reflected in sovereign credit default swaps. The literature in this field is fairly young, but quickly evolving. The fourth article extends the work on credit default swaps to the corporate sector and investigates liquidity frictions which perturb the arbitrage relationship between the synthetic and cash fixed income markets.

The first paper, *Sovereign Credit Default Swap Premia* provides an introduction to the topic by surveying the literature on sovereign credit default swap spreads. Credit derivatives have experienced dramatic growth over the last decade. Far from uncontroversial, they are often blamed as a vehicle for speculation with detrimental effects on countries' borrowing costs. Proponents of the products, on the other hand, cite them as efficient products to enhance risk sharing in financial markets. By emphasizing certain contradictions in the literature and confronting them with stylized statistical facts, I intend to raise some thought-provoking questions in light of the changing regulatory landscape surrounding the use of sovereign credit default swap spreads. The spotlight has so far been put on the determinants of spreads, financial market frictions as well as spillover and contagion effects. In addition, I also point to areas which would require further research to allow us to fully understand the implications which would justify recent regulatory initiatives. One big debate in the literature surrounds the question whether sovereign credit default swap spreads are determined relatively more by country-specific factors, or rather by a set of global risk factors unrelated from an individual's country economy. Chapters two and three of this thesis contribute explicitly to this debate.

The second paper, *Real Economic Shocks and Sovereign Credit Risk*, focuses on the nature of global risk factors for the pricing of sovereign spreads. The strong comovement of country credit spreads has motivated investigations into the role of common factors in explaining time variation in spreads. While the bulk of the literature almost unanimously refers to global financial market factors as the ultimate source of risk, Roméo Tédongap and I provide new empirical evidence that unspanned global macroeconomic risk bears some responsibility for the strong co-movement in sovereign spreads. To rationalize these findings, we embed a reduced-form default process into an equilibrium model with downside risk for CDS spreads. Countries differ through their sensitivity to global macroeconomic forecasts and uncertainty. In addition, we exploit the high frequency information in the CDS term structure across 38 countries to estimate the structural model. Our estimated parameters prove consistent with preference for early resolution of uncertainty. Both the empirical evidence and the model's ability to match stylized asset pricing facts in several dimensions confirm the existence of time-varying risk premia in sovereign spreads as a compensation for exposure to common U.S. business cycle risk. The macroeconomic nature of our global risk factors, namely expected growth and volatility of US consumption growth, thus stand in contrast to the commonly cited role of US financial risk.

The financial crisis of 2008/2009 was accompanied with severe losses by financial institutions. While several governments already struggled with fiscal imbalances, bank bailouts put further strains on sovereign balance sheets. This strengthened the link between sovereign credit risk and the domestic financial sector and put the spotlight back on country-specific factors as determinants of sovereign spreads. In particular, research increasingly emphasized the private-to-public risk transfer as well as feedback effects to the private sector. These may arise when deteriorating sovereign financial health weakens the value of implicit bailout guarantees given to financial institutions and causes collateral damage to the value of their public bond holdings. The third paper, *The Term Structure of CDS Spreads and Sovereign Credit Risk* responds to the previous literature by arguing that in fact both global and country-specific risk factors matter in determining the price of sovereign credit risk. However, they simply matter in different points in time. I argue that the term structure of credit spreads provides an informative signal beyond the level of spreads about the relative importance of global and domestic risk. In particular, global shocks determine spread changes when the slope is positive. Nonetheless, a negative slope indicates that domestic shocks are relatively more important. To draw these conclusions, I develop a recursive preference-based model with long-run risk for credit default swaps. The underlying default process, which modulates expectations about future default probabilities, depends both

on global macroeconomic uncertainty and country-specific risk. Their dynamics and investor preferences jointly explain time variation in the term structure. I evaluate the model using a panel of 44 countries and I show empirically that the country-specific fundamentals explain relatively more spread variation than global factors as countries become more distressed. The number of months the term structure is inverted proxies for the duration of distress. One important message of the paper is that we ought to focus more often on the slope of the term structure, beyond merely looking at the level of spreads.

The fourth and final paper, *Squeezed Everywhere - Disentangling Types of Liquidity and Testing Limits-to-Arbitrage*, moves away from sovereign credit risk and investigates no-arbitrage frictions in the relationship between synthetic and cash fixed income products in the corporate market. Theoretically, the spread on a par floating rate note over a risk-free interest rate should reflect the same underlying credit risk as an insurance on the underlying debt obligation. This arbitrage relationship broke severely down, however, during the financial crisis. The CDS-Bond basis, defined as the difference between a credit default swap spread and a bond spread over a risk-free benchmark for the same underlying, turned significantly negative over an extended period of time. In this article, I focus on disentangling asset-specific, market-wide and funding liquidity in the CDS-Bond basis outside and during the 07/09 financial crisis, stressing the importance of separating different types of liquidity. I show that while asset-specific liquidity is cross-correlated in both the cash and derivative market, funding and market liquidity matter only for the former. Using different types of liquidity, I also test several theoretical predictions of limits-to-arbitrage. I find strong evidence in favor of the margin-based asset pricing theory and flight-to-quality effects. In addition, both asset-specific and funding liquidity are mutually reinforcing with market-wide liquidity, while there is little commonality between firm-specific and funding liquidity.

The remainder of this thesis consists of the four papers introduced above. Each of them represents a separate chapter. Accompanying tables and figures follow each article and a summarized bibliography follows at the end of the thesis.