Philipp Neelmeier

Risk Assessment of Covered Bonds in the International Secondary Market

– An Empirical Analysis –

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Philipp Neelmeier
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Zusammenfassung der Dissertation

Risk Assessment of Covered Bonds in the International Secondary Market – An Empirical Analysis –

Covered Bonds sind verzinsliche Wertpapiere, die von Finanzinstituten emittiert werden und durch Vermögenswerte besichert sind, welche zu einer Deckungsmasse, dem sogenannten Cover Pool, zusammengefasst werden. In der großen Mehrheit der Fälle handelt es sich bei diesen Vermögensgegenständen entweder um gewerbliche oder private Hypothekendarlehen oder Kredite an öffentliche Stellen, z. B. Staaten oder sonstige Gebietskörperschaften. Die durch diese Arten von Vermögensgegenständen besicherten Covered Bonds werden dementsprechend als Hypotheken-Covered-Bonds (Mortgage Covered Bonds) bzw. öffentliche Covered Bonds (Public Covered Bonds) bezeichnet. In den vergangenen zwei Jahrzehnten entwickelten sich Covered Bonds zu einer der wichtigsten Arten von verzinslichen Wertpapieren, was sich u. a. in einem ausstehenden Emissionsvolumen von nahezu 2,5 Billionen Euro per Jahresultimo 2016 widerspiegelt. Die Größe der Anlageklasse zeigt die Bedeutung von Covered Bonds für die emittierenden Banken, für öffentliche und private Schuldner und für Investoren. Die emittierenden Banken nutzen Covered Bonds als Refinanzierungsinstrument und fassen die Kredite der Schuldner in den Cover Pools zusammen. Anschließend werden die Covered Bonds als risikoarme Anlagemöglichkeit an Investoren veräußert. Covered Bonds bieten den Banken somit eine kosteneffiziente Refinanzierungsmöglichkeit für öffentliche bzw. Hypothekenkredite und spielen daher eine entscheidende Rolle bei der Kreditvergabe. Für Investoren besteht der größte Vorteil von Covered Bonds in der durch die Deckungsmasse begründeten höheren Sicherheit gegenüber unbesicherten Anleihen. Im Falle der Insolvenz des Emittenten besitzen die Investoren einen vorrangigen Anspruch auf Rückzahlung ihrer Forderungen aus den im Cover Pool enthaltenen Vermögenswerten. Aufgrund dieses vorrangigen Anspruchs und da die Insolvenz des Emittenten in der Regel nicht automatisch zur vorzeitigen Fälligkeit des Covered Bonds führt, wurden Covered Bonds in der Vergangenheit häufig als nahezu ausfallrisikofrei angesehen. Dies drückte sich u. a. in sehr guten Ratings aus. Allerdings ist diese Ansicht aufgrund von Verwerfungen an den Finanzmärkten, sinkenden Immobilienpreisen in zahlreichen Ländern sowie dem aufkommenden Bewusstsein, dass auch öffentliche Kredite ein nicht unerhebliches Ausfallrisiko aufweisen können, nicht mehr uneingeschränkt vertretbar. Dies zeigt sich beispielsweise in einem deutlichen Rückgang der durchschnittlichen Covered-Bond-Ratings der drei großen Ratingagenturen in Folge der Finanzkrise nach dem Zusammenbruch der Investment Bank Lehman Brothers. Daher wird es sowohl für die emittierenden Banken als auch für Investoren zunehmend wichtiger, den Preisbildungsprozess von Covered Bonds zu verstehen.

Vor diesem Hintergrund besteht das Ziel der vorliegenden Dissertation darin, die Risikobewertung von Covered Bonds im internationalen Sekundärmarkt zu untersuchen. Der Fokus liegt hierbei zum einen auf der Analyse der Einflussfaktoren von Risikoprämien von öffentlichen und Hypotheken-Covered-Bonds, zum anderen auf der Quantifizierung

der Auswirkungen von Ratingänderungen auf die Preise von Covered Bonds. In Kapitel 2 werden zunächst Covered Bonds detailliert beschrieben und es werden Unterschiede im Vergleich zu Verbriefungen aufgezeigt, welche ebenfalls ein Refinanzierungsinstrument für Banken darstellen. Der Hauptunterschied besteht darin, dass im Falle von Covered Bonds die zur Deckung bestimmten Vermögenswerte auf der Bilanz der emittierenden Bank verbleiben, wohingegen bei einer Verbriefung eine vollständige Veräußerung der Kredite an eine Zweckgesellschaft stattfindet. Darüber hinaus werden die Ratingmethoden der drei großen Ratingagenturen Fitch, Moody's und Standard & Poor's dargestellt und es zeigt sich, dass alle drei Ratingagenturen ein Rating der emittierenden Bank als Ausgangspunkt für die Ableitung des Covered-Bond-Ratings verwenden. Abschließend wird die regulatorische Behandlung von Covered Bonds für Banken und Versicherungsunternehmen dargestellt, da diese einen großen Anteil der ausstehenden Covered Bonds als Investoren erworben haben.

Anschließend werden in Kapitel 3 die Einflussfaktoren von Risikoprämien öffentlicher Covered Bonds mithilfe einer empirischen Analyse untersucht. Aufbauend auf einer Darstellung bereits veröffentlichter Studien in Bezug auf Einflussfaktoren von Risikoprämien von Covered Bonds werden zunächst spezifische Forschungsfragen formuliert, welche im Anschluss analysiert werden. Mithilfe von Random- und Fixed-Effects-Regressionen wird ein Paneldatensatz untersucht, welcher die wöchentlichen Risikoprämien verschiedener öffentlicher Covered Bonds im Zeitraum von 2006 bis 2012 enthält. Es zeigt sich u. a., dass neben Covered-Bond-spezifischen Faktoren auch makroökonomische Variablen einen Einfluss auf die Risikoprämien öffentlicher Covered Bonds besitzen. Weiterhin wird gezeigt, dass die Finanzkrise sowie die sich anschließende Staatsschuldenkrise zu höheren Risikoprämien führten, wohingegen das erste von der Europäischen Zentralbank als Reaktion auf die Finanzkrise aufgelegte Covered-Bond-Ankaufprogramm zu geringeren Risikoprämien führte. Darüber hinaus werden Unterschiede zwischen in verschiedenen Ländern und Währungen emittierten öffentlichen Covered Bonds untersucht. Hierbei werden insbesondere für den deutschen Pfandbrief-Markt Unterschiede im Vergleich zu Covered Bonds aus anderen Ländern festgestellt.

In Kapitel 4 werden anschließend – ebenfalls mithilfe von Random- und Fixed-Effects-Regressionen – Einflussfaktoren von Risikoprämien von Hypotheken-Covered-Bonds analysiert und Unterschiede im Vergleich zum vorherigen Kapitel untersucht. Bei der Anwendung der Methoden auf einen aus wöchentlichen Risikoprämien von Hypotheken-Covered-Bonds bestehenden Datensatz zeigt sich, dass zahlreiche Einflussfaktoren mit denen von öffentlichen Covered Bonds übereinstimmen. In einer gemeinsamen Analyse der beiden verwendeten Datensätze können allerdings Unterschiede hinsichtlich des Einflusses von makroökonomischen Variablen, welche zusätzlich die Qualität der Cover Pools der beiden betrachteten Covered-Bond-Arten beschreiben, gezeigt werden.

In Kapitel 5 werden schließlich im Rahmen einer umfassenden Ereignisstudie die Auswirkungen von Herauf- bzw. Herabstufungen von Ratings auf die Preise von Covered Bonds untersucht. Bei der Durchführung der Ereignisstudie wird die Heteroskedastizität der Renditen verschiedener Covered Bonds explizit berücksichtigt, indem das von Bessembinder et al. (2009) vorgeschlagene Matching-Portfolio-Model zur Berechnung der abnormalen Renditen verwendet wird und indem die abnormalen Renditen anschließend durch die Division durch ihre empirische Standardabweichung standardisiert werden, wie von Ederington et al. (2015) vorgeschlagen. Da die Ratingmethoden der drei großen Ratingagenturen zur Ermittlung des Covered-Bond-Ratings alle eine Einschätzung der Bonität des Emittenten als Ausgangspunkt haben, werden sowohl Rating-Ereignisse bezüglich des Covered-Bond-Ratings als auch bezüglich des Emittentenratings analysiert. Es zeigt sich, dass negative Rating-Ereignisse für beide betrachteten Arten von Ratings zu signifikanten abnormalen Renditen führen, wohingegen für positive Ereignisse keine oder nur sehr geringe Auswirkungen festzustellen sind. Im Rahmen einer Analyse der Einflussfaktoren der Höhe der (standardisierten) abnormalen Renditen von Covered Bonds wird gezeigt, dass die abnormalen Preisreaktionen am stärksten ausfallen, wenn das Rating vom Investment-Grade- in den Speculative-Grade-Bereich herabgestuft wird. Abschließend werden die Ergebnisse mit Studien, in welchen die Auswirkungen von Rating-Ereignissen auf Unternehmensanleihen untersucht wurden, verglichen. Hierbei lässt sich feststellen, dass die abnormalen Preisreaktionen für Covered Bonds deutlich geringer ausfallen, was u. a. auf das bessere Durchschnittsrating von Covered Bonds zurückzuführen ist.

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Hannover, November 2018

Philipp Neelmeier

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Nomenclature

Abbreviations

ABR	Abnormal Bond Return
ABS	Asset Backed Securities
AR	Abnormal Return
AUD	Australian Dollar
BMR	Benchmark Return
bp	Basis Point
CAC 40	Cotation Assistée en Continu 40 index (French stock market index)
CAD	Canadian Dollar
CBPP	Covered Bond Purchase Program
cf.	Confer
CHF	Swiss Franc
CRA	Credit Rating Agency
CRR	Capital Requirements Regulation
DAX	Deutscher Aktienindex (German stock market index)
DKK	Danish Krone
D-Cap	Discontinuity Cap
ECB	European Central Bank
ECBC	European Covered Bond Council
EEA	European Economic Area
e.g.	Exempli Gratia
EL	Expected Loss
EUR	Euro
et al.	Et alii
f.	Following page
FE	Fixed Effects
ff.	Following pages
Fitch	Fitch Ratings

FTSE 100	Financial Times Stock Exchange 100 Index
GBP	Great Britain Pound/Pound Sterling
GDP	Gross Domestic Product
GLS	Generalized Least Squares
iid	Independent and Identically Distributed
JPY	Japanese Yen
JRL	Jurisdictional-supported rating level
LIBOR	London Interbank Offered Rate
Max	Maximum
MBS	Mortgage Backed Securities
Min	Minimum
Moody's	Moody's Investors Service
NIBOR	Norwegian Interbank Offered Rate
NOK	Norwegian Krone
Obs.	Observations
OLS	Ordinary Least Squares
p.	Page
PD	Probability of Default
PIIGS	Portugal, Ireland, Italy, Greece, Spain
RRL	Reference Rating Level
SABR	Standardized Abnormal Bond Return
SAR	Standardized Abnormal Return
SCR	Solvency Capital Requirement
sd	Standard Deviation
SEK	Swedish Krona
S&P	Standard & Poor's Ratings Services/Standard & Poor's Global Ratings
TPI	Timely Payment Indicator
UK	United Kingdom (of Great Britain and Northern Ireland)
U.S.	United States (of America)
USD	United Staes Dollar

Mathematical Symbols

$1_{\{\}}$	Indicator variable
$ABR_{i,t}$	Abnormal return of bond i at time t
$AR_{j,t}$	Abnormal return of covered bond program j at time t
$BMR_{i,t}$	Benchmark return of bond i at time t
ln	Natural logarithm
k	Rating event
m	Number of independent variables
n_+	Number of positive observations of iid random variables
$P_{i,t}$	Price of bond i at time t
$R_{i,t}$	Return of bond i at time t
r_i	Signed ranks of observations of iid random variables
s^2	Estimator of the variance of iid random variables
$SABR_{i,t}$	Standardized abnormal return of bond i at time t
$SAR_{j,t}$	Standardized abnormal return of covered bond program j at time t
$spread_{i,t}$	Asset swap spread of bond i at time t
T_{t-test}	Test statistic of the t-test
$T_{signed-rank}$	Test statistic of the (Wilcoxon) signed-rank test
$T_{signed-rank,+}$	Alternative test statistic of the (Wilcoxon) signed-rank test
$u_{i,t}$	Error term
$V()$	Variance
$X_{i,t}$	Matrix of variables varying between bonds and over time
$\bar{X}$	Arithmetic mean of iid random variables
Y_i	Matrix of variables varying only between bonds
z	z-score of a test statistic
Z_t	Matrix of variables varying only over time
β_0	Constant
β_1	Coefficient of the first crisis period
β_2	Coefficient of the second crisis period
β	Vector of coefficients in a regression analysis
$\widehat{\beta}_{FE}$	Fixed effects estimate of β
$\widehat{\beta}_{RE}$	Random effects estimate of β
δ	Vector of coefficients in a regression analysis
γ	Vector of coefficients in a regression analysis
μ	Expected value of iid random variables
σ	Standard deviation of iid random variables
$\sigma_{i,k}$	Standard deviation of bond i for event k

τ_1	First border between different time periods
τ_2	Second border between different time periods
ω_i	Weight of bond i in a covered-bond program

1 Introduction

1.1 Problem Definition and Objective of This Work

Covered bonds are interest-bearing securities issued by financial institutions and backed by assets combined in a cover pool. In the vast majority of cases, these assets are either residential or commercial mortgages (mortgage covered bonds) or loans to public sector entities (public covered bonds). With a history that goes back to the 18th century, covered bonds played a crucial role in the financial market for a long time, until changes in the inter-bank market resulted in a marked decline of their relevance in the middle of the 20th century. However, the issuance of the first German benchmark Pfandbrief[1] in 1995 triggered a remarkable comeback of the asset class.[2] Consequently, covered bonds evolved into one of the most important classes of interest-bearing securities with a total volume outstanding of nearly €2.5 trillion at the end of 2016.[3]

The large size of the asset class shows the importance of covered bonds for issuing banks (which use them as a refinancing tool), for public and private creditors (whose loans are combined in the cover pool), and for investors seeking low-risk investment options. The banks act as financial intermediaries when issuing covered bonds by combining several small-sized loans granted to creditors (who often have no possibility of obtaining the loan directly from the capital market) in a cover pool and refinancing these combined loans with large-sized covered bonds sold to large-scale investors. Thus, covered bonds are a

[1]Pfandbrief is the name for the German covered-bond type.
[2]See Grossmann et al. (2014).
[3]See ECBC (2017a, Ch. 5).

cost-effective refinancing tool for mortgage or public-sector loans and they therefore play a crucial role for credit supply and financial stability. The high importance of covered bonds as a refinancing tool can also be seen in the European Central Bank's (ECB) launch of three covered bond purchase programs, during which the ECB purchased covered bonds in the primary and secondary markets.[4]

For investors, the greatest advantage of covered bonds is the dual recourse they have against the issuer and the cover assets. In case of issuer insolvency, investors have a preferential claim to the assets in the cover pool and a claim to the remaining insolvency estate equal to that of other creditors.[5] For this reason, covered bonds were often considered as substitutes for government bonds, and therefore almost default-risk-free, in the past.[6] However, due to distortions in the financial markets affecting the international banking world, declining housing prices in several countries and the awareness that even government bonds might contain substantial default risk, this notion is likely to have changed. Therefore, for issuing banks and investors it becomes increasingly important to know what factors influence the risk premiums of covered bonds.

In the literature, previous studies investigating factors influencing risk premiums of covered bonds often focus on the German Pfandbrief market.[7] However, the German Pfandbrief market is the largest component of the international covered-bond market. Thus, corresponding results might not hold for covered bonds issued in other countries. Furthermore, there exist different covered-bond laws in different countries and the assets in the cover pool are often domestic. Therefore, it is likely that differences in the factors influencing risk premiums exist between covered bonds issued in different countries. Thus, one goal of this thesis is to investigate factors influencing risk premiums in the international covered-bond market, that is, risk premiums of covered bonds issued in several different countries and currencies. Concerning studies investigating risk pre-

[4]See Section 3.2.2 or the ECB's website (https://www.ecb.europa.eu) for more details.
[5]See Schwarcz (2011).
[6]The term default-risk-free is appropriate in this context because in the vast majority of the existing covered-bond laws, insolvency of the issuer does not automatically lead to an acceleration of the covered bond, see http://www.ecbc.eu/framework/list. Instead, the bond-holders' claims are satisfied from the assets in the cover pool as scheduled, leading to no default of the covered bond.
[7]See, e.g., Kempf et al. (2012); Koziol and Sauerbier (2007); Breger and Stovel (2004); Herbert and Birkmeyer (2002); Herges (2000); Rees (2001); Prokopczuk et al. (2013).

miums of covered bonds in the international market, often mortgage and public covered bonds are examined together.[8] However, it is likely that there exist different influencing factors of risk premiums for these two covered-bond types. Thus, another goal of this thesis is to investigate the influencing factors of risk premiums separately for mortgage and public covered bonds. While risk premiums of mortgage covered bonds have been studied before,[9] the literature lacks a comprehensive study examining factors influencing risk premiums of public covered bonds in the international market and this thesis aims to fill this gap. Since risk premiums of mortgage covered bonds have thus far only been investigated in a few countries, in addition to examining public covered bonds, another objective of this thesis is to investigate risk premiums of mortgage covered bonds in more detail. Moreover, after examining both covered-bond types separately, differences between the factors influencing risk premiums between the two types are investigated.

As mentioned above, covered bonds cannot be considered entirely risk-free anymore. This can also be seen when looking at the average ratings of covered bonds. Covered bonds generally have a higher rating than senior unsecured bonds due to the dual recourse investors have against the issuer and the cover pool. Although this statement still holds, following the financial crisis after the collapse of Lehman Brothers, the average covered-bond rating decreased significantly for all three major credit rating agencies (CRAs) ‘Fitch Ratings’ (Fitch), ‘Moody’s Investors Service’ (Moody’s), and ‘Standard & Poor’s Ratings Services’/‘Standard & Poor’s Global Ratings’[10] (S&P), i.e., several covered bonds have been downgraded. In the literature, studies investigating other asset classes often verify decreasing prices and thus, increasing risk premiums following rating downgrades, but no price effects around upgrades. Concerning covered bonds, however, no study has investigated the effects of positive or negative rating events thus far and due to the dual recourse it might well be that price effects around rating events are different. Furthermore, since covered-bond ratings generally depend on the issuer rating, there might also be differences in the effects of rating changes between the issuer or the

[8] See, e.g., Volk and Hillenbrand (2006); Packer et al. (2007); Bujalance and Ferreira (2010).
[9] See, e.g., Prokopczuk and Vonhoff (2012).
[10] Standard & Poor’s Ratings Services changed its name to Standard & Poor’s Global Ratings on 27 April 2016.

bond rating. Therefore, another objective of this thesis is to investigate whether prices of covered bonds react to changes of the issuer or the bond rating.

Summarizing the statements above, the main focus of this thesis is on the risk assessment of covered bonds in the international secondary market. More precisely, the objective is to investigate the following three important research questions in more detail:

- What are the main factors influencing risk premiums of covered bonds?
- What differences exist between public and mortgage covered bonds with regard to the factors influencing the covered bonds' risk premiums?
- Do the prices of covered bonds react to rating changes and, if so, do differences exist in the covered bonds' price reactions if either the issuer rating changes or if the bond rating changes?

All three research questions are examined with empirical analyses. To answer the first two questions, regression estimation techniques for panel data are used. First, only public covered bonds are investigated because the literature dealing with risk premiums of covered bonds in the international market mainly focuses on mortgage covered bonds or investigates both covered-bond types together, as mentioned above. Subsequently, building on the results obtained for public covered bonds, mortgage covered bonds as well as both covered-bond types together are investigated to study differences in the factors influencing the two covered-bond types. The third research question is investigated using an event study methodology specifically controlling for the peculiarities of the bond market that do not exist in the stock market, such as different ratings and maturities.

Our results on the knowledge of factors influencing risk premiums of covered bonds are particularly relevant for issuing banks and for covered-bond investors. Particularly during crisis periods with concomitant high risk premiums, issuers have an incentive to send signals to investors and thereby possibly lower their refinancing costs. For this purpose, knowing the factors that influence risk premiums is essential. Covered-bond investors, on the other hand, can consider the results in their investment decisions. By considering the typical factors influencing covered bond risk premiums in the international secondary market, investors might be able to detect possibly anomalously priced covered bonds and to exploit such anomalies. Second, they can use the results in their risk management processes related to the covered bonds they are invested in. In the context of their risk management processes, the knowledge of the price reaction of covered bonds following rating changes is also highly relevant and beneficial for covered-bond investors. For example, they can consider the results in their scenario analyses regarding potential losses in market value resulting from negative rating events. This is particularly important for the ECB, which holds a significant amount of covered bonds as a consequence of the recent covered bond purchase programs.

1.2 Course of Investigation

To analyze the research questions stated in the previous section, the thesis is structured as follows. In Chapter 2, some fundamentals of covered bonds are presented. First, Section 2.1 mentions the essential features a bond has to fulfill to qualify as a covered bond, describes the international covered-bond market, and reveals several differences between covered bonds and asset backed securities (ABS) and mortgage backed securities (MBS), respectively. Subsequently, Section 2.2 describes why ratings are particularly important for covered bonds, and gives a short overview about the rating methodologies of the three major CRAs. Finally, Section 2.3 explains the basics of the regulatory treatment of covered bonds.

Chapter 3 deals with the first of the three research questions stated above. More specifically, the factors influencing risk premiums of public covered bonds are investigated. First, Section 3.1 gives a short motivation why it is important to examine public covered bonds separately from mortgage covered bonds and it provides a literature overview concerning factors influencing risk premiums of covered bonds. Section 3.2 describes the importance of public covered bonds for the funding of local and regional governments. Furthermore, several more specific research questions, which will be examined during the empirical analyses, are derived. Subsequently, Section 3.3 describes the dataset used in the empirical analyses. The results of the analyses are presented in Section 3.4 before a short conclusion with a summary of the results is provided in Section 3.5.

After examining public covered bonds, Chapter 4 focuses on the investigation of factors influencing risk premiums of mortgage covered bonds. Again, the chapter starts with a short motivation in Section 4.1. Section 4.2 describes the dataset before the results of the empirical analyses are presented in Section 4.3. To answer the second of the three research questions stated above, in addition to the investigation of the factors that influence risk premiums of only mortgage covered bonds, the differences that exist compared to the factors influencing risk premiums of public covered bonds are also examined using a combined dataset comprising the risk premiums of both covered-bond types. Section 4.4 summarizes the results.

The objective of Chapter 5 is to answer the third and last of the three research questions stated above. Therefore, this chapter examines the effects of rating changes on covered-bond prices. Analogous to the previous chapters, first, Section 5.1 provides the motivation. Section 5.2 discusses the research question in more detail before Section 5.3 provides a description of the empirical methodology. Subsequently, Section 5.4 describes the dataset used in the empirical analyses and Section 5.5 reports the results of the analyses. Finally, Section 5.6 contains a short summary of the results.

2 Fundamentals of Covered Bonds

As mentioned in the introduction, the main objectives of this work are to analyze secondary-market risk premiums of covered bonds and to quantify the effects of rating events on secondary-market covered-bond prices. Against this background, in this chapter, we want to present some fundamentals of covered bonds, first. In Section 2.1, we define the term covered bond and describe essential features of this asset class. Furthermore, we highlight differences compared to asset backed securities and mortgage backed securities. Subsequently, in Section 2.2, we elaborate on covered-bond ratings. We explain why ratings are especially important in this asset class and we shortly present the different approaches of the three major CRAs Fitch, Moody's, and S&P. Finally, we describe the regulatory treatment of covered bonds for banks and insurance companies in Section 2.3.

2.1 Covered Bonds

2.1.1 Definition and Description

The European Covered Bond Council (ECBC)[11] defines covered bonds as bonds with the following four essential features, which have to be stipulated by national law (either a special covered-bond legislation or the general law). First, either the issuer is a credit institution subject to public supervision and regulation, or, if the bond is issued by a

[11] The ECBC was founded in 2004, has over 100 members in 26 covered-bond jurisdictions, and describes itself a platform that brings together covered-bond market participants, see http://www.ecbc.eu. Accessed: 22 March 2018.

Special Purpose Vehicle (SPV), the bondholders have full recourse to the credit institution using the SPV to issue covered bonds. Second, in case of issuer insolvency, investors have a preferential claim against the so-called cover pool comprising certain financial assets. Third, the credit institution must ensure that the cover pool comprises sufficient financial assets to fulfill investors' claims at all times. Fourth, there exists public or independent supervision of the credit institution's obligations concerning the cover pool.[12]

In short, covered bonds are interest-bearing securities issued by financial institutions[13] and backed by assets combined in a cover pool. Besides mortgages or loans to public-sector entities, there can be other types of collateral, for example, ships or planes,[14] but these covered-bond types have only a marginal market share.[15] There is no separate cover pool for each covered bond. One cover pool generally backs several covered bonds from the same financial institution with different issue and maturity dates, as well as different issue sizes; together, all of these covered bonds are called a covered-bond program. Coupon and principal payments to covered-bond investors do not have to be satisfied by cash flows generated from the cover pool. However, as mentioned above, if the issuer becomes insolvent, covered-bond investors have a preferential claim against the assets in the cover pool and, in addition, an equal claim to the remaining insolvency estate as investors in unsecured debt. Thus, investors have a dual recourse against both the cover assets and the issuer.[16]

Because the essential features stated above have to be stipulated by national law, the specific design of a covered bond varies from country to country. As of 2016, there exists a special covered-bond legislation in 23 European countries and seven countries outside the European Economic Area (EEA).[17] The national laws prescribe several components of covered bonds, for example, the type of cover assets and the minimum amount of

[12]See ECBC (2017b).
[13]Regardless of whether the covered bond is actually issued by the financial institution itself or by an SPV, we will refer to the financial institution as the issuer or the issuing bank in the following.
[14]See Grossmann et al. (2014).
[15]See ECBC (2016, Ch. 5).
[16]See Schwarcz (2011).
[17]See Grossmann and Stöcker (2016, p. 131).

overcollateralization.[18] With a share of approximately 15% of the outstanding covered-bond volume at the end of 2016,[19] the German Pfandbrief remains the largest component of the asset class but with a declining tendency; at the end of 2008, the German Pfandbrief represented more than a third of the entire asset class.[20] Concerning issuance volumes, in recent years, covered bonds from Denmark, France, Italy, Spain, and Sweden have occasionally already exceeded that of Germany.[21] An overview of the outstanding covered-bond volume is presented in Figure 2.1.[22]

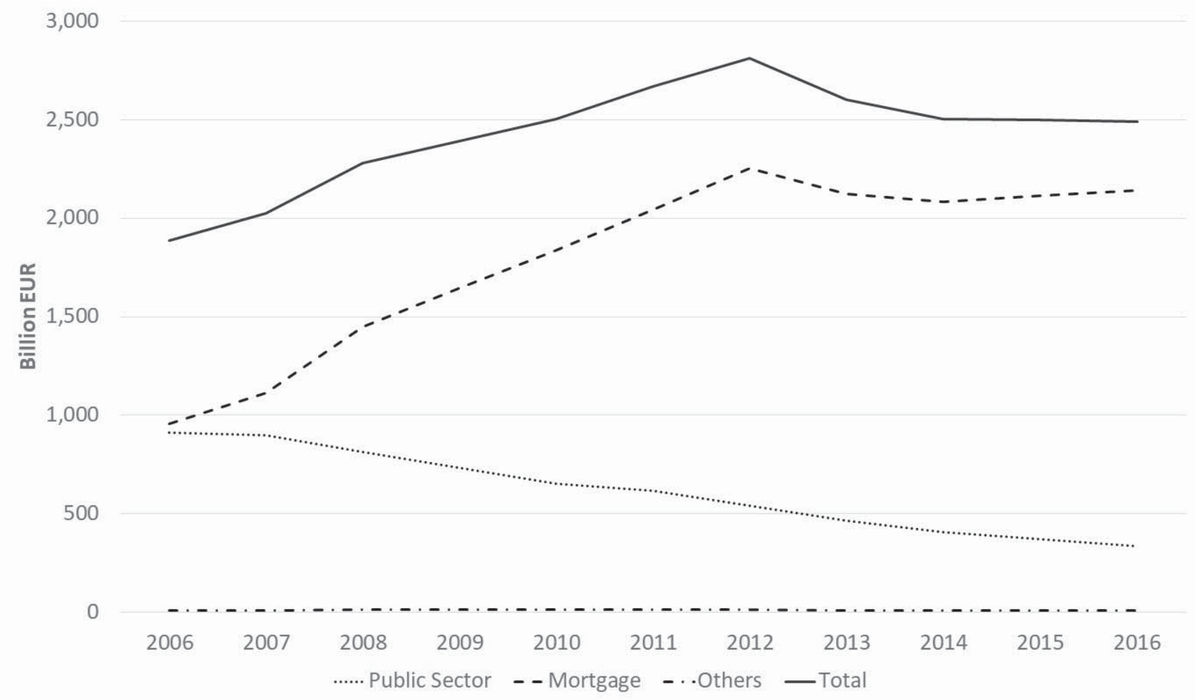

Figure 2.1: **Outstanding Covered-Bond Volume.[23]**
This figure shows the outstanding covered-bond volume between 2006 and 2016 for the entire covered-bond market and divided into mortgage covered bonds, public covered bonds, and other covered bonds.

[18] Overcollateralization describes the percentage the value of the cover pool must be higher than the total value of all covered bonds backed by this cover pool.
[19] See ECBC (2017a, p. 589).
[20] See ECBC (2009, p. 359).
[21] See ECBC (2013, 2014, 2015, 2016, 2017a, Ch. 5).
[22] In Spain, besides normal covered bonds, there also exist so-called multi-issuer Cédulas. Cédulas is the short version of 'Cédulas Hipotecarias' or 'Cédulas Territoriales', respectively, the Spanish types of covered bonds. Multi-issuer Cédulas are securities, in which several issuers combine their covered-bond issuances. The new security is then backed by cash-flows from the combined covered bonds, and thus, the structure resembles that of a CDO.
[23] Source: ECBC (2016, Ch. 5), ECBC (2017a, Ch. 5).

The outstanding covered-bond volume increased steadily from 2006 to a peak in 2012 and, after a slight drop, it remained fairly stable afterwards, with a total outstanding volume of nearly €2.5 trillion at the end of 2016, as already mentioned in the introduction. However, the development of the outstanding volume is significantly different for public covered bonds and mortgage covered bonds. In 2006, the outstanding volume of both covered-bond types was nearly equal, with €915bn (public) and €958bn (mortgage), respectively. After that, however, analogous to the entire market, the outstanding volume of mortgage covered bonds increased until 2012 and remained relatively stable in subsequent years, whereas the outstanding volume of public covered bonds decreased steadily. At the end of 2016, the corresponding outstanding volumes are €336bn (public) and €2,143bn (mortgage). The considerable decline of the outstanding volume of public covered bonds can almost completely be attributed to a decline of the outstanding volume of public German Pfandbriefe. Following the German re-unification in 1990, the high demand for capital by the German public sector led to a steep increase in the outstanding volume of public Pfandbriefe and, consequently, to a very high share of German Pfandbriefe in the international public-covered-bond market. However, a reduced demand by the German public sector and, in particular, the abolition of state guarantees for German Landesbanken in 2005 led to the significant decline in the outstanding volume over the last decade. However, the outstanding volume of public covered bonds actually increased in several other countries during this period, showing that public covered bonds remain an important part of the international capital market.[24]

2.1.2 Differences Compared to ABS/MBS

As mentioned above, covered bonds are used by the issuing bank as a refinancing tool. Another possibility for banks to refinance their loans is to securitize them and to use an SPV to issue ABS or, in the case of mortgage loans, MBS. At first glance, covered bonds and ABS/MBS appear to be quite similar since both combine several financial assets in a pool used as collateral. However, there are significant differences between these two

[24] See Berninger (2016, p. 120).

types of assets. The main difference is that in case of covered bonds, the issuing bank is fully responsible for the satisfaction of the investors' claims; the cover assets are only used as collateral and they remain on the balance sheet of the issuing bank. Even if the covered bonds are issued by an SPV, investors have full recourse against the financial institution,[25] leading to a high incentive for the financial institution to thoroughly monitor the cover assets in both cases. In case of ABS/MBS, on the other hand, the pool of assets is transferred via a 'true sale' to an SPV, resulting in investors having recourse only to the pool of collateral transferred to the SPV; they have no recourse to the financial institution originating the loans.[26] Thus, all claims of the investors have to be satisfied by the securitized assets. A further difference is that in case of covered bonds the cover pool is dynamic, i.e., issuers have to replace non-performing loans or add new loans if the pool diminishes in value. By contrast, securitizations have a static pool of collateral, i.e., losses resulting from non-performing loans have to be borne by the investors since these loans do not have to be replaced with new loans by the originator.[27] Thus, from an investor's point of view, due to the dual recourse against both the cover pool (of which the quality has to be maintained over the life of the covered bond) and the issuer in case of covered bonds compared to a recourse only against a static pool of collateral in case of ABS/MBS, covered bonds are seen as significantly less risky. The advantage for the financial institution of using covered bonds instead of securitizations as a refinancing tool is that the interest payments to investors are generally lower than for ABS/MBS. In return, however, since the cover assets remain on the issuer's balance sheet and non-performing loans have to be replaced, the issuer still bears the risk of the assets in the cover pool.[28]

[25] See Volk (2011) for more details on how the SPV and the financial institution are related with each other if the covered bond is issued by an SPV.

[26] See Choudhry et al. (2005, p. 217ff.).

[27] See ECBC (2016), Volk (2011, p. 109).

[28] More information about the differences between covered bonds and securitizations can be found in Boesel et al. (2016) or Schwarcz (2011).

2.2 Covered-Bond Ratings

While in 2007, prior to the financial crisis following the collapse of Lehman Brothers, the relative share of AAA-ratings[29] was 97% for S&P, 91% for Fitch, and 80% for Moody's, this amount decreased to 64% for S&P, below 60% for Fitch, and even below 50% for Moody's in 2012/2013. Subsequently, the share of top ratings increased but has not yet reached the pre-crisis level.[30] While ratings were quite stable prior to the financial crisis, rating changes have become more frequent in the recent decade. Against this background, quantifying the effects of rating changes on covered-bond prices has become highly important, and therefore, we will empirically investigate the effects of rating changes on covered-bond prices in Chapter 5. In the current section, we will therefore provide some background information concerning covered-bond ratings. In Section 2.2.1, we explain why ratings are particularly important for covered bonds and in Section 2.2.2, we give a short overview about the rating methodologies of the three major CRAs.

2.2.1 The Importance of Covered-Bond Ratings

Ratings play a pivotal role in reducing information asymmetries even concerning covered bonds. Although in many countries, regular disclosures about the composition of the cover pool are prescribed by the law and many issuers voluntarily publish regular information about the cover pools backing their covered bonds, the richness of detail of the information is often still insufficient. However, for a meaningful assessment of a covered bond's quality, both the issuer and the cover pool have to be appraised. Therefore, Hillenbrand and Schulz (2012) come to the following conclusion:

> *"[...]in the absence of 1. a technically clean possibility to perform quality assessments and 2. a broad mass of issuers publishing at least random sample data, the only chance investors and analysts have is to use ready-made assessments by rating agencies."*

[29] Here and in the following, we do not explicitly mention both the rating codes of Moody's and of Fitch/S&P. We simply write AAA, AA, and so on, even if the rating comes from Moody's and should therefore be Aaa, Aa, and so on. Furthermore, we do not differentiate between AA+, AA, and AA-, but we simply write AA. The same holds true for A+, A, and A-, and so on.

[30] See Nord/LB (2016, p. 469f.).

Therefore, credit rating agencies are particularly important in alleviating the problem of asymmetric information in this asset class, as they have access to more detailed information about the cover pools.

2.2.2 Methodologies

Due to the dual recourse investors have against the issuer and the cover pool, in the rating of a covered bond, both the solvency of the issuing financial institution and the quality of the cover pool have to be considered in order to reflect a realistic assessment of the quality of the covered bond. Hence, the covered-bond rating methodologies of the credit rating agencies all have the financial strength of the issuing financial institution as a starting point,[31] and the covered-bond rating is generally higher than that of the issuer. The exact bond rating then depends on the cover-pool quality, among others. As credit rating agencies assess the quality of an entire cover pool, all covered bonds of the same covered-bond program have the same credit rating. Nevertheless, we use the terminology '(covered-)bond rating' instead of 'covered-bond program rating'. In the following subsections, we give a brief overview about the methodologies used by the three major CRAs.[32]

2.2.2.1 Fitch

Fitch's covered-bond rating methodology consists of three steps. In the first step, the floor for the covered-bond rating is determined. For this purpose, Fitch uses the issuer default rating as a starting point. In jurisdictions where covered bonds are excluded from bail-in regulations, the issuer default rating can be uplifted by up to three notches, leading to the rating floor.

[31] See Forster and Purwin (2014); Dierick (2016).

[32] In the case of Spanish multi-issuer Cédulas, different series of such multi-issuer Cédulas have different backing portfolios, leading to different risk profiles, see Garcia Muñoz (2009), and, thus, different rating histories.

In the second step, Fitch determines the maximum achievable covered-bond rating. In this context, the so-called *Discontinuity Cap* (D-Cap) is determined. In the D-Cap analysis, the risk of payment interruptions is examined if, following issuer insolvency, instead of the issuer, the cover pool is the source of payment. In this context, the segregation of the cover pool from the remaining assets of the issuer as well as gaps between the maturities of the cover assets and the covered bonds are examined. Eventually, the D-Cap indicates the number of notches the covered-bond rating can be above the rating floor on a probability of default (PD) basis. The D-Cap values range from zero (covered bond default is expected immediately after default of the issuer) to eight (minimal discontinuity risk), but usually, the values lie between one and six. In addition to a PD-based analysis, Fitch further examines the expected recovery rate following a default after the transition of the payment source from the issuer to the cover pool, increasing or reducing the maximum covered-bond rating by up to two notches in the investment-grade spectrum and up to three notches in the speculative-grade spectrum.

In the third and final step, Fitch examines the effects of several stress scenarios on the assets in the cover pool, e. g., higher credit risk, higher liquidity risk, or unfavorable developments of the interest-rate curve or foreign exchange rates. Beginning with the maximum achievable rating as 'target', Fitch tests what level of overcollateralization of the cover pool needs to be maintained to justify the target rating. If the level of overcollateralization is too low, the target rating is reduced and the necessary level of overcollateralization for the new target rating is determined. When the overcollateralization is sufficient to justify the target rating, the target rating constitutes the final covered-bond rating.[33]

2.2.2.2 Moody's

The covered-bond rating methodology of Moody's consists of two steps:

- Moody's Expected Loss Covered Bond Model (EL Model),

[33]See Muñoz and Mezza (2016) and Nord/LB (2016, pp. 471ff.).

- Moody's Timely Payment Indicator (TPI) framework.

As its name implies, in the first step, Moody's calculates the expected loss for covered-bond investors. Therefore, Moody's uses the counterparty risk assessment of the issuer (plus one notch in most European countries) as the so-called covered bond anchor, describing the probability that the issuer defaults (and, consequently, that the cover pool is the source of payment). The default of the issuer is accordingly called a covered bond anchor event. Subsequently, Moody's examines whether, following a covered bond anchor event, the assets in the cover pool are sufficient to fulfill the investors' claims. For this purpose, a stressed environment is assumed. Analogously to the methodology of Fitch, stress with regard to the credit risk, liquidity/refinancing risk, interest-rate risk, and currency risk is alleged. Moody's calculates the estimated loss on the cover assets in the stressed environment, and together with the probability of a covered bond anchor event, the expected loss is computed. This is conducted on a month-by-month basis, and the summed up and discounted monthly expected losses give the aggregate expected loss on the covered bond. Depending on the level of the expected loss, a rating is assigned to the covered bond.

In the second step (the TPI framework), Moody's examines the probability of timely payments to the investors following a covered bond anchor event. The TPI can have six different specifications, ranging from 'very improbable' to 'very high', and it is generally determined on a jurisdiction-by-jurisdiction basis. However, it can be adjusted for individual covered-bond programs. Depending on the the assessments of the covered bond anchor and the TPI, a maximum covered-bond rating is determined. The final covered-bond rating is then determined by the lower of the rating resulting from the EL model and the maximum rating resulting from the TPI framework.[34]

[34]See Soldera et al. (2016) and Nord/LB (2016, pp. 474ff.).

2.2.2.3 Standard & Poor's

S&P uses a four-step-methodology to obtain a covered-bond rating. In the first step, it is examined whether the covered-bond rating can be higher than the issuer credit rating from a legal/regulatory point of view. The main question is whether the cover assets can be segregated from the remaining insolvency estate of the issuer in case of issuer insolvency. If this is the case, the covered-bond rating can be higher than the issuer credit rating.

In the second step, S&P determines the so-called reference rating level (RRL). In jurisdictions with resolution regimes allowing issuers to service covered bonds even after a default of their unsecured debt, the RRL is the issuer credit rating plus one or two notches. In jurisdictions without such resolution regimes, the RRL equals the issuer credit rating.

The third step consists of the analysis of the cover pool and of potential jurisdictional support in case of issuer insolvency. Jurisdictional support is expected if the cost (with regard to the entire economy) of a failure of a covered-bond program would be higher than that of support by, e.g., the government or the central bank. In this context, the covered-bond legislation, the importance of the covered-bond market in the jurisdiction, and the sovereign's credit worthiness are examined, leading to a potential uplift of up to three notches above the RRL, resulting in the jurisdictional-supported rating level (JRL). The JRL can be further uplifted in the course of the analysis of the cover pool. For example, S&P analyzes whether the amount of overcollateralization is sufficient in stress scenarios with regard to credit risk and refinancing risk, and whether liquidity is sufficient for at least six months. An uplift of up to four notches above the JRL is possible, leading to the maximum achievable covered-bond rating.

In the fourth and final step, the results of the previous steps are combined and the final covered-bond rating is determined. For this purpose, external factors such as counterparty risks and country risks are examined. Dependent of the outcome of these risks' assessment the maximum achievable covered-bond rating can either be confirmed or reduced, leading to the final covered-bond rating.[35]

2.3 Regulatory Treatment

According to Caris (2014), banks and insurance companies form a large group of covered-bond investors and concerning the regional distribution, the vast majority of covered bonds are held by European investors. In Europe, banks and insurance companies have to fulfill the regulatory requirements of Basel III and Solvency II, respectively, concerning the underlying of risky assets with equity capital. In both sets of regulations, covered bonds enjoy a preferential treatment compared to unsecured bonds.[36] To be eligible for a preferential treatment, in both the Basel III and the Solvency II regulation, covered bonds have to fulfill the requirements of Article 52(4) of the UCITS Directive 2009/65/EC.[37] UCITS stands for ‘Undertakings for Collective Investments in Transferable Securities’, which is the official term for an investment fund. The UCITS Directive 2009/65/EC contains, among others, investment limits concerning certain assets for investment funds and in Article 52(1) of the Directive, it is stated that an investment fund is not allowed to invest more than 5% of its assets in securities of the same issuer. However, in Article 52(4), this limit is raised to 25% if the following requirements are fulfilled:

- The bond has to be issued by a financial institution registered in the European Union.

- For the protection of the bond-holders, the financial institution has to be subject to special public supervision defined by law.

[35]See Paciotti and Farina (2016) and Nord/LB (2016, pp. 477ff.).
[36]See Will (2016) and Eichert (2016).
[37]In the Solvency II regulation, in some cases there is a reference to Article 22(4) of the UCITS Directive 85/611/EEC instead of a reference to Article 52(4) of the UCITS Directive 2009/65/EC, see EIOPA (2014), for example. However, UCITS Directive 85/611/EEC was repealed by UCITS Directive 2009/65/EC and the ‘old’ Article 22(4) became the ‘new’ Article 52(4).

- The capital obtained from the issuance of the bonds shall be invested in specific assets defined by law. Over the entire life of the bond, the assets must be sufficient to cover the bond-holders' claims and in case of insolvency of the issuer, the assets are primarily used to repay the principal and accrued interest to the investors.

There are two peculiarities in this definition. First, the term 'covered bond' is not explicitly mentioned in the article and no specific requirements regarding possible types of cover assets are defined. Second, covered bonds issued in countries outside the European Union can never fulfill these requirements, which is why we rely on the ECBC's definition of covered bonds, as described in Section 2.1.1. However, since both the Basel III and the Solvency II regulations require covered bonds to fulfill these requirements for a preferential treatment, covered bonds issued in countries outside the European Union will not benefit from the advantageous regulations.

In the following two sections, we describe the regulations of Basel III and Solvency II concerning covered bonds. After a short overview of the basic principles of the specific guideline, we will present the extent of the preferential treatment in more detail in both sections.

2.3.1 Basel III

As in the Basel II regulation, the basic idea of the capital requirements of the Basel III regulation is that a bank's total equity capital must be at least 8% of the bank's risk-weighted assets.[38] This means that each of the bank's assets is multiplied by a risk weight (as a percentage of the invested amount), and the bank has to underlay the sum of these risk-weighted assets with at least 8% equity capital.

An essential part of the implementation of the Basel III regulations concerning the underlying of risky assets with equity capital is the Capital Requirements Regulation

[38] See Basel Committee on Banking Supervision (2010, p. 12).

(CRR)[39]. In the CRR, covered bonds are addressed in Article 129. As mentioned above, there is a reference to Article 52(4) of the UCITS Directive 2009/65/EC, and in Article 129, the term 'covered bond' is explicitly used. Moreover, several requirements concerning the assets contained in the cover pool, which covered bonds have to fulfill to be eligible for the preferential treatment, are stated. In general, loans to public-sector entities, residential or commercial property-mortgage loans and even ship-mortgage loans are eligible but there are certain restrictions regarding maximum Loan-to-Value (LTV) ratios of the individual assets.[40] If these requirements are fulfilled, such covered bonds have a lower risk weight compared to unsecured bonds, i.e., banks investing in such covered bonds have to underlay the investments with less equity capital.

According to Article 129, if the covered bond is rated AAA or AA, the risk weight is 10% compared to 20% for exposures to financial institutions or exposures to corporations with the same rating, as defined in Article 120 and Article 122, respectively. Thus, a bank has to underlay a AAA- or AA-rated covered bond with equity capital in the amount of only 0.8% of the total investment, compared to 1.6% for uncovered exposures with an AAA- or AA-rating.[41] If the covered bond is rated A or BBB, the risk weight is 20% compared to 50% or even 100% for uncovered exposures. The risk weight increases to 50% for covered bonds with a BB- or B-rating and 100% for covered bonds with a lower rating, compared to 100% and 150%, respectively, for exposures to equivalently-rated financial institutions or corporations.[42] An overview of the risk weights is presented in Table 2.1.

If the covered bond is not rated, the risk weight is derived from the issuer rating and the same (preferential) risk weights as stated above hold.[43] Since all three rating agencies use the issuer rating as the starting point for the assessment of the covered-bond rating, a

[39] Regulation (EU) No 575/2013 of the European Parliament of the Council of 26 June 2013 on prudential requirements for credit institutions and investment firms and amending Regulation (EU) No 648/2012.
[40] An overview about the requirements can be found in Will (2016, pp. 151f.).
[41] 8% of the 10% risk weight compared to 8% of the 20% risk weight.
[42] See Will (2016, p. 153) and Articles 120-122 and 129 of the CRR.
[43] See Article 129(5) of the CRR.

Table 2.1: **Risk Weights According to the CRR.**[44]
This table presents the risk weights of covered bonds, corporate bonds, and exposures to financial institutions according to the CRR.

Rating	**AAA/AA**	**A**	**BBB**	**BB**	**B**	**<B**
Covered bond risk weight	10%	20%	20%	50%	50%	100%
Corporate bond risk weight	20%	50%	100%	100%	150%	150%
Financial institution risk weight	20%	50%	50%	100%	100%	150%

covered-bond rating cannot be lower than the issuer rating, as mentioned in Section 2.2.1. Hence, using the issuer rating if no covered-bond rating is available seems reasonable.

Thus, in the banking regulation, both public and mortgage covered bonds issued in the European Union enjoy a preferential treatment compared to (uncovered) corporate bonds or (uncovered) exposures to financial institutions.

2.3.2 Solvency II

Analogous to banks having to underlay risky assets with equity capital within the context of the Basel III regulations, insurance companies have to underlay risky assets with equity capital within the context of Solvency II. The minimum amount of equity capital an insurance company has to hold is determined by the so-called Solvency Capital Requirement (SCR), which is a measure covering all quantifiable risks of an insurance company. It has to be calculated using either a prescribed standard formula or an internal model.[45] In the following, we focus on the specific regulations concerning covered bonds in the standard formula.

In Subsection 2 of Section 4 of Directive 2009/138/EC[46] (Articles 103–111), the basic principles of the SCR-calculation using the standard formula are described and the rules are specified in Annex IV of the Directive. For the SCR-calculation, there exist several risk modules. For each risk module, an SCR is calculated and these risk-module-SCRs

[44] Based on Will (2016, p. 153).
[45] See Bourdeau (2009, pp. 194ff.).
[46] Directive 2009/138/EC of the European Parliament and of the Council of 25 November 2009 on the taking-up and pursuit of the business of Insurance and Reinsurance (Solvency II).

are then combined using a predetermined correlation matrix. Covered bonds are part of the market risk module, which consists of several sub-modules. For each sub-module, an SCR is calculated and these sub-module-SCRs are combined to the risk-module-SCR, again using a predetermined correlation matrix. The specific calibration of the SCR-calculation using the standard formula is given in the Commission Delegated Regulation (EU) 2015/35[47]. In Section 5 of the Delegated Regulation, the calibration of the market risk module is specified. Covered bonds are mainly affected by the spread risk sub-module described in Subsection 5.5 of the Delegated Regulation.

The spread-risk sub-module accounts for risks of potential changes in credit spreads.[48] The capital requirement for spread risk is dependent of the rating and the duration of a bond. The higher the duration or the lower the rating, the higher is the capital requirement. Covered bonds enjoy a preferential treatment compared to unsecured bonds only if they are rated AAA or AA and fulfill the requirements of Article 52(4) of the UCITS Directive 2009/65/EC.[49] The capital requirement for AAA-rated covered bonds is 0.7% per year if the duration is up to five years compared to 0.9% per year for AAA-rated corporate bonds. For each additional year of duration, the additional capital requirement is 0.5% in both cases. For AA-rated covered bonds, the capital requirement is 0.9% per year if the duration is up to five years and 0.5% for each additional year of duration. In contrast to that, the capital requirement for AA-rated corporate bonds is 1.1% per year for the first five years of the duration, 0.6% for every additional year up to ten years, and 0.5% per year for longer durations. For both corporate and covered bonds with lower ratings, the capital requirements are equal. An overview of the capital requirements is presented in Table 2.2.

[47] Commission Delegated Regulation (EU) 2015/35 of 10 October 2014 supplementing Directive 2009/138/EC of the European Parliament and of the Council on the taking-up and pursuit of the business of Insurance and Reinsurance (Solvency II).
This Regulation is relevant for the entire EEA and not only for the EU. In the following, we will reference this as *the Delegated Regulation*.

[48] Note that the risk of potential changes of the (risk-free) interest rates is considered in a separate interest-rate-risk sub-module, see Subsection 5.2 of the Delegated Regulation.

[49] See Article 180 of the Delegated Regulation. In this Article, the term 'covered bond' is explicitly mentioned but in contrast to the Basel III regulation, no specific requirements concerning the cover assets are mentioned.

[49] See (Eichert, 2016, p. 157) and Articles 176 and 180 of the Delegated Regulation.

Overall, covered bonds may receive a preferential treatment under Solvency II. However, two things are worth noting. First, capital requirements concerning covered bonds are considerably higher under Solvency II than under Basel III. As mentioned in the previous subsection, the capital charge for AAA-rated covered bonds under Basel III is only 0.8%, independent of the duration. Under Solvency II, on the other hand, the capital charge depends on the duration and it is 3.5% for AAA-rated covered bonds with a duration of five years, for example, and 8.5% if the duration is 15 years.[50] Second, the advantageousness of covered bonds compared to equivalently-rated corporate bonds exists only for AAA- and AA-ratings, and even for these, it is rather low.

[50]It has to be kept in mind, however, that the sub-module-SCRs and the superordinated risk-module-SCRs for the different (sub-)modules are not simply added up but are combined using predefined correlation matrices, as mentioned above.

Table 2.2: **Capital Requirements in the Spread Risk Sub-Module.**
This table presents the capital requirements in the spread risk sub-module of the Solvency II regulations for covered bonds and uncovered corporate bonds, dependent on the rating and the duration of the bond. The table is based on (Eichert, 2016, p. 157).

	Duration D (in years)				
Rating	**≤ 5**	**5–10**	**10–15**	**15–20**	**20+**
AAA	0.9% * D	4.5% + 0.5% * (D-5)	7.0% + 0.5% * (D-10)	9.5% + 0.5% * (D-15)	12.0% + 0.5% * (D-20)
AA	1.1% * D	5.5% + 0.6% * (D-5)	8.4% + 0.5% * (D-10)	10.9% + 0.5% * (D-15)	13.4% + 0.5% * (D-20)
A	1.4% * D	7.0% + 0.7% * (D-5)	10.5% + 0.5% * (D-10)	13% + 0.5% * (D-15)	15.5% + 0.5% * (D-20)
BBB	2.5% * D	12.5% + 1.5% * (D-5)	20% + 1.0% * (D-10)	25% + 1.0% * (D-15)	30% + 0.5% * (D-20)
BB	4.5% * D	22.5% + 2.5% * (D-5)	35% + 1.8% * (D-10)	44% + 0.5% * (D-15)	46.5% + 0.5% * (D-20)
unrated	3.0% * D	15% + 1.7% * (D-5)	23.5% + 1.2% * (D-10)	29.5% + 1.2% * (D-15)	35.5% + 0.5% * (D-20)
AAA covered	0.7% * D	3.5% + 0.5% * (D-5)	6.0% + 0.5% * (D-10)	8.5% + 0.5% * (D-15)	11% + 0.5% * (D-20)
AA covered	0.9% * D	4.5% + 0.5% * (D-5)	7.0% + 0.5% * (D-10)	9.5% + 0.5% * (D-15)	12% + 0.5% * (D-20)

3 Empirical Analysis of the International Public Covered-Bond Market[51]

3.1 Motivation and Literature Overview

While central governments regularly issue bonds to obtain money from the capital market, a large share of local and regional governments (LRGs) in European countries has to rely on bank loans as the primary source of funding since their funding needs are generally too small for obtaining money from the capital market by direct bond issuance. For banks providing such loans to LRGs, one of the most, if not the most important refinancing tool is public covered bonds.[52] Thus, public covered bonds play a key role in refinancing LRG funding needs, and they contribute to lower funding costs of public sector entities.[53] Since these funding costs depend on the refinancing costs of the banks providing the loans, among others, it is important to know the factors influencing these banks' refinancing costs. Against this background, in this chapter, we investigate what factors influence

[51] This chapter is mainly based on the article „Empirical Analysis of the International Public Covered-Bond Market" which is a joint work with Marc Gürtler and was published in the *Journal of Empirical Finance* (Gürtler and Neelmeier, 2018a). The authors are grateful to the participants of the 28th Australasian Finance and Banking Conference, Sydney, the Southern Finance Association Annual Meeting 2015, Captiva Island, and the 2015 Research Colloquium in Finance, Accounting, and Taxes, Göttingen, for helpful suggestions and comments.

[52] See Berninger (2016).

[53] See Grossmann et al. (2014).

risk premiums of public covered bonds in several different countries and denominated in several different currencies.

As mentioned in the introduction, covered bonds, and particularly public covered bonds, have often been regarded as almost default-risk-free in the past because investors considered them as substitutes for government bonds. One reason for this is that creditors of LRGs often expect LRGs to be bailed out by the central government in times of financial distress.[54] However, due to distortions in the financial markets affecting the international banking world (e.g., the financial crisis following the collapse of Lehman Brothers) and in particular due to the awareness that the quality of government debt might differ between different countries and might (in some countries) contain substantial default risk, as seen during the recent sovereign debt crisis, the notion of public covered bonds being entirely risk-free has partially changed. Therefore, for issuing banks, it becomes increasingly important to know the factors influencing risk premiums of public covered bonds in order to control their refinancing costs. Since the cover pools consist of loans to (mostly domestic) public sector entities, it is highly likely that there exist differences in factors influencing risk premiums between public covered bonds issued in different countries, and for LRGs, it is crucial to know these influencing factors since they directly affect their funding costs.

We are the first to thoroughly investigate factors influencing risk premiums in the international public covered-bond market. We show that in addition to being affected by bond-specific factors, risk premiums of public covered bonds are also affected by several country-specific macroeconomic factors. In doing so, we explicitly show significant international differences between covered-bond markets, and we show increasing effects of the recent financial crisis and the sovereign debt crisis on risk premiums of public covered bonds. Furthermore, we investigate the effects of two covered bond purchase programs enacted by the ECB. We show that while the first program led to lower risk premiums, a similar effect cannot be verified for the second program.

[54]See Jenkner and Lu (2014).

Previous studies investigating risk premiums of covered bonds often investigate mortgage and public covered bonds together. Several of these studies focus on the German Pfandbrief market. Some studies consider yield spreads between covered bonds and German sovereign bonds (*BUNDs*) to exist largely due to liquidity differences.[55] Other studies investigate whether factors other than illiquidity have an effect on risk premiums.[56] Prokopczuk et al. (2013) investigate the German Pfandbrief market and show that the quality of the cover pool significantly affects risk premiums of covered bonds and that there exist significant differences between mortgage and public covered bonds in Germany. Moreover, there exist studies of the international covered bond market.[57] However, all these studies either investigate only country averages or only mortgage covered bonds or they leave out macroeconomic variables.[58]

In summary, almost all previous studies either investigate mortgage and public covered bonds together or only mortgage covered bonds. However, it is possible that there might exist different factors influencing risk premiums for these two covered-bond types in the international market. Risk premiums in the international covered-bond market have thus far often been investigated only based on country averages, leaving out covered bond-specific influences. However, as mentioned above, particularly during the recent sovereign debt crisis, default risk of public debt and thus, the quality of public covered bonds' cover pools varied significantly between different countries, leading to differences between public covered bonds issued in different countries. Therefore, the literature lacks a comprehensive study of bond-individual risk premiums of public covered bonds issued in different countries that considers possible covered bond-specific and macroeconomic

[55] See Kempf et al. (2012); Koziol and Sauerbier (2007).

[56] See Breger and Stovel (2004); Herbert and Birkmeyer (2002); Herges (2000); Rees (2001).

[57] See Volk and Hillenbrand (2006); Packer et al. (2007); Bujalance and Ferreira (2010); Prokopczuk and Vonhoff (2012).

[58] Recently, Pinto and Correia (2017) published an empirical study of covered bond-individual risk premiums for both public and mortgage covered bonds separately. Furthermore, in their recently published article, Markmann and Zietz (2017) investigate the effects of the covered bond purchase programs on covered-bond indices in different countries. However, as mentioned above, this chapter is based on Gürtler and Neelmeier (2018a), which was submitted to the Journal of Empirical Finance before the two mentioned studies were published. Furthermore, Pinto and Correia (2017) even reference an earlier version of Gürtler and Neelmeier (2018a). Thus, we will not reference Pinto and Correia (2017) and Markmann and Zietz (2017) in the following.

influencing factors and investigates the effects of recent economic crises and monetary policy measures by the ECB.

Our analyses make the following contributions to the literature. We provide the first study investigating factors influencing risk premiums in the international public covered-bond market on a bond-individual level. By using a broad dataset with more than 70,000 observations between 2006 and 2012 of 560 public covered bonds issued in ten different countries and eight different currencies, we provide a detailed overview of factors influencing risk premiums in the international secondary public covered-bond market. In doing so, we show the influences of covered bond-specific factors, macroeconomic variables, and exogenous events such as the ECB's purchase programs on risk premiums.[59] To the best of our knowledge, this is the first study investigating the long-term effects of the recent sovereign debt crisis and the covered bond purchase programs by the ECB mentioned in the introduction on risk premiums in the international covered-bond market at a bond-individual level.[60] In our empirical analysis, we show substantial differences regarding the influencing factors for public covered bonds issued in different countries or different currencies. Particularly for the German Pfandbrief market, we find differences in influencing factors compared to public covered bonds issued in other countries that can be linked to German sovereign debt having been seen as *safe-haven investments*. Furthermore, we are the first to use the threshold regression method for panel data developed by Hansen (1999) to determine the borders between the pre-crisis period, the financial crisis, and the sovereign debt crisis. Other studies determine these borders solely based

[59] We use the asset swap spread as a proxy for the risk premium. Because the asset swap spread measures the credit risk of a bond over LIBOR or an equivalent interbank interest rate, it might be argued that it does not describe the true risk premium of a bond. Nevertheless, there are good reasons to use this proxy as a measure for the risk premium. First, it is generally difficult to find risk-free rates of interest because even government bonds are not entirely risk-free. Second, the asset swap spread is frequently used in the empirical literature, leading to good comparability with our results. Third, data availability is very much better than for other measures of risk; thus, we use it as the dependent variable in our regression analyses.

[60] The effect of the sovereign debt crisis on individual bond risk premiums has heretofore only been investigated for the German Pfandbrief market, see Prokopczuk et al. (2013). For a few other countries, the effect has only been investigated on an index level together with the effect of the first covered bond purchase program by the ECB, leaving out bond-specific factors and in particular, not differentiating between covered bonds with different types of collateral, see Beirne et al. (2011). For the second covered bond purchase program, short-term effects at the announcement date have been shown, see Schuller (2013); Szczerbowicz (2015).

on specific incidents. However, as there are several economically justifiable borders, the appropriate points in time are difficult to define that way. Using threshold regressions solves this problem and leads to statistically substantiated borders. Naturally, we check the obtained borders for economic reasonability to exclude statistical artifacts. Finally, we are the first to use fixed and random effects estimations to analyze covered bond risk premiums, leading to unbiased estimates of the effects of the explanatory variables.

The organization of the remainder of this chapter is as follows. In the next section, we describe the importance of public covered bonds in the international market and derive several research questions we want to investigate in our empirical analyses. Subsequently, we describe our dataset in Section 3.3. We present the results of our analyses in the fourth section before we provide a short conclusion with a summary of the results in Section 3.5.

3.2 The Importance of Public Covered Bonds and Research Questions

3.2.1 The Importance of Public Covered Bonds

As mentioned in the motivation, public covered bonds are particularly important to refinancing bank loans to LRGs in European countries. In most of Europe, the local public sector is responsible for a variety of duties, for example, the functioning of the education system, local and regional infrastructure, or the supply of drinking water. Consequently, more than half of public sector investments in Europe are conducted by LRGs, and therefore, low funding costs are crucial. However, while LRGs regularly issue bonds in the United States (so-called municipal bonds), for example, only a few LRGs are able to obtain money directly from the capital market through the issuance of bonds in Europe; most LRGs' funding needs are too small. In fact, almost 80% of outstanding LRG bonds in Europe are issued by German federal states. Thus, in other European countries, the amount of outstanding LRG bonds is negligible. Therefore, most LRGs have to rely on bank loans as the primary source of funding, and these loans are often provided by issuers of public covered bonds, which use these bonds as a refinancing tool for the loans to the LRGs.[61] As another funding source for LRGs in several European countries, there also exist public agencies enjoying implicit or explicit guarantees by the central government. These agencies cover most of local governments' funding needs, leading to small or non-existent public covered-bond markets in these countries.[62] In the two largest public covered-bond markets, Germany and France, more than 40% of local government debt is provided by public covered bond issuers at the end of 2015, and in Spain, it is still almost one third.[63] This shows the high importance of public covered bonds for the funding of LRGs.

According to Nord/LB (2016), 46 banks have outstanding public covered bonds with a minimum volume of €500 million. Only six of these 46 banks solely issue public covered bonds; the other 40 banks also issue mortgage covered bonds. Thus, the issuing institutions are not generally specialized in the issuance of loans to public sector entities.

3.2.2 Research Questions

In this section, we derive several research questions regarding possible influencing factors of risk premiums of public covered bonds. The specific variables we use to investigate these research questions in our empirical analysis will be presented in Section 3.3.

The effects of bond-specific factors on risk premiums of (mortgage) covered bonds have already been investigated in the literature.[64] Possible bond-specific influencing factors can be proxies for the credit risk of the covered bonds (e.g., the bond rating) and for liquidity risk (e.g., issue size, bid-ask-spread) or other factors (coupon, country). However, no study has incorporated all the mentioned factors in the same analysis. Moreover, there might

[61] See Berninger (2016).
[62] See Berninger (2013).
[63] See Berninger (2016).
[64] See e.g., Packer et al. (2007); Prokopczuk and Vonhoff (2012); Prokopczuk et al. (2013).

be additional bond-specific factors influencing risk premiums, for example, the issuing bank. In addition, the effects of bond-specific factors have not yet been examined for public covered bonds in the international covered-bond market. Therefore, in the present chapter, we want to investigate the following:

> *Research Question 1: What bond-specific factors influence risk premiums of public covered bonds?*

Since public covered bonds are backed by loans to public sector entities, it is highly likely that the investors' risk assessment depends on the macroeconomy. If the economic situation becomes aggravated globally or in a specific country, there is a higher probability that the assets included in the cover pool would diminish in value because, in an extreme case, public sector entities might have problems obtaining new money from financial institutions or in the capital market. At the same time, investors might be under pressure to sell assets because they need liquid funds. This would lead to a decline in prices and an increase in risk premiums. Therefore, in addition to bond-specific variables, risk premiums of public covered bonds might also be affected by macroeconomic factors.

Only a few studies have investigated the effects of macroeconomic factors on risk premiums of covered bonds. Bujalance and Ferreira (2010) include factors representing the development of the European stock market as well as the general interest rate level and obtain different results for covered bonds from Germany, France, and Spain. Beirne et al. (2011) include several macroeconomic factors in their analyses of average covered bond risk premiums in different countries and the entire euro area. However, apart from a surprisingly positive effect of the five-year overnight indexed euro swap rate, they do not present the effects, because they only include the variables as controls. Prokopczuk and Vonhoff (2012) include country-specific macroeconomic factors in their analysis of euro-denominated mortgage covered bonds in France, Germany, Spain, and the UK. Besides a stock market factor and the general interest rate level, they further include stock market volatility and real estate indices in their analysis. Because, as mentioned in Section 2.2.1, transparency regarding the composition of the cover pools is very heterogeneous in different countries and also between different covered bonds, and thus, detailed cover-pool information is not obtainable for all covered bonds, the real estate indices are seen as proxies for the cover pool quality in the four different countries. However, real estate indices also describe a part of the macroeconomic situation in a country and can therefore also be a possible factor influencing risk premiums of public covered bonds. Furthermore, as mentioned in the previous subsection, most issuers of public covered bonds also issue mortgage covered bonds. Thus, they hold significant shares of their assets in mortgages and therefore, a real estate index can also be seen as an indication of the quality of the issuing banks' balance sheets, in which investors of public covered bonds should also be interested in due to the dual recourse they have.

A real estate index is the only macroeconomic factor investigated in the literature so far that is not directly related to the capital market. Particularly for public covered bonds, however, such macroeconomic factors not directly related to the capital market probably have an influence on risk premiums because they describe the situation of the debtors of the cover pool assets. As mentioned in the motivation section of this chapter, it is widely believed that the central government will bail out LRGs in times of financial distress. Therefore, the debt-to-GDP ratio of a country might be a reasonable proxy for the quality investors assigned the cover pools. Furthermore, there are several other factors describing the macroeconomy and, thus, at least partly also the cover pool quality, which could have an effect on risk premiums. Because no study has so far investigated the impact of the macroeconomic situation in a country on the risk premiums of public covered bonds in detail while controlling for bond-specific factors, we want to examine the following:

Research Question 2: What influence do macroeconomic factors have on risk premiums of public covered bonds?

Besides macroeconomic factors, there can sometimes be exogenous events that might have an effect on risk premiums of public covered bonds, such as economic crises or extraordinary monetary policy measures by a central bank. Because macroeconomic factors might react to such events themselves, parts of the effects of such events on risk premiums should be incorporated in the effects of macroeconomic factors. However, the effects of the macroeconomic factors potentially do not contain the entire effects of such events, and therefore, they have to be investigated separately. Against this background, we want to investigate the following:

> *Research Question 3: What influence do exogenous events have on risk premiums of public covered bonds?*

Because different types of events might have different effects, we further split this research question into two parts. First, an example of such an event might be the financial crisis following the collapse of Lehman Brothers on 15 September 2008. Although the subprime crisis was already in progress at that time, the failure of such a huge financial institution unsettled the faith of market participants in the banking system and, thus, at least partly in covered bonds.[65] Rudolf and Hillenbrand (2009) highlight the increased mistrust in the banking system. A failure of a covered bond requires a failure of the issuing bank followed by a failure of the cover pool. Before the crisis, the first requirement had already been considered extremely unlikely, but, unexpectedly, it was within the realm of possibility. Furthermore, they show that the increase of swap spreads of covered bonds on an index level was massive shortly after the collapse of Lehman Brothers compared with the subprime crisis. They explain this increase with the fact that in existing market conditions, the liquidation of the cover pool could take longer than planned. Thus, although the effect of the financial crisis might be incorporated partly in the effects of the macroeconomic factors, it should be considered separately because the collapse of Lehman Brothers had not been anticipated by market participants.

As the capital market was overcoming the financial crisis, the sovereign debt crisis began. This crisis can be seen as another exogenous event. In contrast to the first crisis, which directly affected the entire global capital market, the latter occurred only in a few countries in Europe, or, more specifically, in the euro area. It again unsettled investors' faith in the capital market. This mistrust in the entire capital market and, in particular, in investments in countries directly affected by the crisis possibly led to higher risk pre-

[65] In the literature, for mortgage covered bonds as well as for the German Pfandbrief market, this effect is considered by splitting the samples in pre-crisis and crisis periods and investigating the effects separately. Prokopczuk and Vonhoff (2012) split their sample already in June 2007 and call the period until May 2009 the crisis period. Since they investigate mortgage covered bonds, treating the subprime crisis as part of the financial crisis might be reasonable. Prokopczuk et al. (2013) further divide their sample into a subprime crisis period starting in July 2007 and a banking crisis period starting on 15 September 2008.

miums during the crisis period. Furthermore, because for many countries, investors' risk assessment of government debt has changed,[66] public covered bonds may be particularly affected by this crisis since the cover pools consist of loans to public sector entities. Again, effects of macroeconomic factors might incorporate (parts of) the effect of the crisis but it should nevertheless be investigated separately. In the existing literature, Beirne et al. (2011) show an increasing effect of the crisis on average swap spreads of both covered-bond types together in the euro area as a whole and in Spain and Ireland in particular. However, their sample ends in July 2010, and their crisis dummy covers less than three months, and due to their investigation of average risk premiums, they had to leave out bond-specific variables.[67] Thus, no study has so far investigated the long-term effects of these crises on bond-individual risk premiums in the international public covered-bond market. Therefore, we want to investigate the following:

> *Research Question 3.1: What effects did the financial crisis and the sovereign debt crisis have on risk premiums of public covered bonds?*

In addition to these crises, which not only affected covered bonds but also the capital market overall, there have been two covered bond purchase programs by the ECB, as mentioned in the introduction.[68] The aims of the programs were similar. The first covered bond purchase program (*CBPP1*) was implemented 'to support a specific financial market segment that is important for the funding of banks and that had been particularly affected by the financial crisis'.[69] The aim of the second program (*CBPP2*) was 'to contribute (a) to easing funding conditions for credit institutions and enterprises and (b) to encouraging credit institutions to maintain and expand their lending to customers'.[70] CBPP1 was announced on 7 May 2009, details of it were published on 4 June 2009, the purchases started in July 2009, and they ended on 30 June 2010. Key characteristics are purchases with a total volume of €60bn, which were conducted in the primary and sec-

[66] See e.g., Beirne and Fratzscher (2013).

[67] Furthermore, analogous to the effects of the financial crisis, at least for the German Pfandbrief market, the influence of the sovereign debt crisis has also been investigated by splitting the dataset and analyzing the related period separately, see Prokopczuk et al. (2013).

[68] In September 2014, the ECB announced its third purchase program. Because our dataset covers the period until the end of 2012 and because the program has not yet been completed, we cannot investigate the effect of this program.

[69] See ECB (2010).

[70] See ECB (2012).

ondary markets within the euro area, and minimum requirements concerning the credit rating and the issue size of eligible covered bonds. CBPP2 was announced on 6 October 2011, technical modalities were published on 3 November 2011, purchases started in November 2011, and they ended on 31 October 2012. The planned total volume was €40bn, again distributed within the euro area primary and secondary markets. Moreover, in addition to minimum requirements concerning the credit rating and issue size, the term to maturity was not allowed to exceed 10.5 years. Whereas the planned amount was exhausted completely during the first program, during the second program, the total amount of purchased covered bonds only reached €16.418bn. The ECB justifies this figure with sufficient demand on the part of investors but with a declining supply of covered bonds.[71] Theoretically, due to the increased demand for covered bonds during the periods of the two programs, controlling for other possible influencing factors, risk premiums of public covered bonds should be expected to decrease. Beirne et al. (2011) investigate the effect of CBPP1 on average secondary market swap spreads of both covered-bond types in different euro area countries and the euro area as a whole. For most countries, they show a direct reduction in average swap spreads at the day of the announcement and a long-term decrease in average swap spreads. Furthermore, they show that the announcement of CBPP1 had no direct effect on UK covered bonds because these were not eligible to be purchased during the program. Schuller (2013) investigates the immediate effect of the announcement and the start of CBPP2 on average euro area covered bond asset swap spreads. No effects similar to those of CBPP1 were found. The start of the program even led to higher spreads in the two following weeks. However, there is no economic justification for this effect; therefore, it most likely resulted from other factors that were not controlled for. To the best of our knowledge, the long-term effect of CBPP2 has not yet been investigated. Furthermore, the effects of CBPP1 have only been investigated for country averages leaving out bond-specific factors that could have changed over time, leading to changes in average risk premiums. Against this background, we want to investigate the following:

> *Research Question 3.2: What effects did the two covered bond purchase programs by the ECB have on risk premiums of public covered bonds?*

[71] See ECB (2012).

So far, we have only discussed the international public covered-bond market as a whole. However, there might be differences regarding factors influencing risk premiums for public covered bonds issued in different countries or denominated in different currencies. For example, investors might have been more skeptical towards public covered bonds issued in countries directly affected by the sovereign debt crisis than towards public covered bonds issued in other countries because their assessment of the quality of the loans to mostly domestic public sector entities in the cover pools might have changed.[72] On the other hand, German BUNDs have been seen as safe-haven investments during recent crises, leading to German public Pfandbriefe possibly having also been seen at least partly as safe-haven investments. Furthermore, despite the steep decline in the outstanding volume in recent years, German Pfandbriefe still represent the largest share in the international public covered-bond market and therefore, investors might have had a higher confidence in this market.

Concerning the currency, although issuance in other currencies has increased in recent years, the vast majority of covered bonds is denominated in euros and public covered bonds are almost exclusively issued in countries within the euro-area.[73] Therefore, public covered bonds issued in other currencies play a minor part in the international market and are mostly issued in foreign currency from the issuer's perspective. Furthermore, to be eligible for being purchased by the ECB during one of the two CBPPs, covered bonds had to be euro-denominated. Therefore, investors might have a different risk assessment regarding non-euro-denominated public covered bonds. Against this background, we want to investigate the following:

> *Research Question 4: What differences exist concerning factors influencing risk premiums of public covered bonds issued in different countries or denominated in different currencies?*

[72] One has to bear in mind, however, that the macroeconomic factors mentioned prior to research question 2 differ between the different countries and thus, already incorporate parts of the differences between the countries.

[73] See ECBC (2014, Ch.5).

3.3 Data

In this section, the compilation of the dataset used for the empirical analyses is described. We first define how we selected our sample of public covered bonds. Second, we introduce the variables we use, and finally, we present descriptive statistics of the obtained data.

3.3.1 Sample Selection

To select our sample of covered bonds, we extracted every bond issued before the end of 2012 with the label 'is covered' from Bloomberg. We restrict the issue size to be at least €250m or the equivalent if issued in another currency, because this is the minimum requirement for euro-denominated covered bonds to be included in 'The BofA Merrill Lynch Euro Covered Bond Index', and therefore, it serves as a reasonable threshold.[74] Moreover, we delete every security that is not labeled 'Pfandbriefe', 'Jumbo Pfandbriefe'[75] or 'covered' (e.g., asset-backed securities or senior secured loans), and we further eliminate floating-rate bonds. To restrict our dataset to public covered bonds, we only keep covered bonds with 'Public Loans' as collateral description. A few covered bonds with 'Public Loans' as collateral description were issued in countries in which there were no public covered bonds, according to the annually published 'ECBC European Covered Bond Fact Book'. We delete these bonds from the dataset. For the remaining covered bonds, we obtain the *asset swap spread* in basis points on a weekly basis for the period from January 2006 to December 2012 as dependent variable. For many covered bonds, no data exist, leading to a reduced sample size. Covered bonds with a remaining term to maturity of less than one year are excluded from the dataset. We further check whether the asset swap spread of an observation is more than three times the standard deviation of asset swap spreads in the entire dataset away from the asset swap spread of the same covered

[74] Technically speaking, a covered bond must have a minimum amount outstanding of at least €250m to be included in the index. However, historical information on compliance with this restriction is not available, leading to the consideration of the issue size instead.

[75] Jumbo covered bonds have a minimum issue size of €1bn, three market makers as a minimum and typically, jumbo covered bonds have been considered more liquid than non-jumbos, see Will and Michaelides (2011).

bond at both the previous and the following date. Since the overall standard deviation is approximately 85.3 bp, this means a positive or negative jump of the asset swap spread of more than approximately 256 bp. There are 31 observations fulfilling this condition. For all these observations, we manually check whether there is an analogous jump or drop in the price of the covered bond. For six observations, this is the case, and therefore, these observations remain in the dataset. For 25 observations, however, asset swap spreads increase by more than 400 bp on average without a noticeable change in the corresponding prices. Furthermore, all these observations belong to the same date, and therefore, they are excluded from the dataset. To further take possible outliers into account but minding differences between countries, we winsorize the data separately for every country at the 0.5% and the 99.5% levels. Finally, our dataset consists of 560 covered bonds with 72,567 observations issued in ten different countries and eight different currencies.

3.3.2 Variables

In the following, we present the variables we use to investigate the proposed research questions. Because, besides with international differences between covered-bond markets, these questions deal with bond-specific and macroeconomic factors as well as exogenous events, we split the variable description into three parts relating to covered bond-specific variables, macroeconomic variables, and event variables. We provide a short explanation for every variable and describe why it is included in our analyses and which direction we expect the effect to have.

3.3.2.1 Covered Bond-specific Variables

For every covered bond in the dataset, we obtain both time-constant and time-variant variables from Bloomberg. First, we obtain the *issuer*, the *country*, and the *currency* in which the covered bond is issued, and we generate dummy variables for each issuer, country, and currency. We further obtain the *coupon* in percentage points, the *maturity* in years, and the issue size in euros, which is calculated using the exchange rate at the date of issuance if the covered bond is denominated in a different currency. We expect the coupon to have an increasing effect on covered bond risk premiums because a higher coupon of a bond implies that a higher amount of money is exposed to reinvestment risk. A long maturity, by definition, implies that the investor must wait longer until the nominal value is paid back. Furthermore, the price uncertainty is higher for a longer maturity. A risk-averse investor wants to be reimbursed for these risks; therefore, we expect maturity to have an increasing effect on risk premiums. For issue size, in contrast, we expect a decreasing effect on covered bond spreads because a high issue size means higher supply and, consequently, more liquidity. However, we logarithmize the issue size because we expect the intensity of the influence of an additional unit of volume to decrease with increasing issue size; we call the variable *logvolume*. Time-variant variables are dummies for the bond rating, which are calculated as the average of the ratings of Fitch, Moody's, and S&P, the *bid-ask-spread*, which is the difference between the ask-price and the bid-price, and the *term to maturity* calculated in years. In general, the rating describes the default risk of covered bonds and has two functions in our analyses. First, as mentioned in Section 2.2.1, if the transparency of a covered bond is low, investors must directly rely on the ratings in their investment decisions to assess the associated default risk.[76] Second, even if detailed cover pool information is available, profound cover pool analyses should result in appraisals similar to the external credit rating. Thus, another function of the bond rating is to serve as a proxy for the cover pool assessment of investors. Moreover, some investors by law must consider external credit ratings, as shown in Section 2.3, and therefore, we expect risk premiums to be significantly higher for worse bond ratings. For less than one percent of observations, we could not receive a bond rating. However, in most of these cases, the observations were the first weeks after the issuance of a bond and a rating was assigned a few weeks later. Since covered-bond ratings are generally quite stable, we assign this rating also to these observations. For two other bonds without a rating, we were able to determine a rating from Thomson Reuters Eikon, and for four bonds, we used the issuer rating. Because only 205 observations of our dataset have a BBB-rating, we treat A-ratings and BBB-ratings as one rating class. The bid-ask-spread serves as a second proxy for the liquidity of a covered bond besides logvolume. A high

[76]See Hillenbrand and Schulz (2012).

bid-ask-spread means less trading and, therefore, less liquidity. Therefore, it should have an increasing effect on covered bond risk premiums. Concerning the term to maturity, the same arguments as for maturity hold; therefore, we expect an increasing effect of this variable on covered bond risk premiums.

3.3.2.2 Macroeconomic Variables

As described prior to research question 2, we subdivide the macroeconomic variables into two types: variables directly related to the capital market and other macroeconomic variables. We begin with describing the capital market-related variables. First, we include one variable for all covered bonds in the dataset, i.e., without any restrictions regarding the currency or the country. As Prokopczuk and Vonhoff (2012) show, the volatility of the stock market in a country can have an increasing effect on risk premiums of mortgage covered bonds. However, to investigate whether stock market volatility is a factor influencing risk premiums of public covered bonds as well, we cannot include country-specific volatility indices, because no such indices exist for several countries in our dataset. However, when comparing weekly quotes of volatility indices for the EURO STOXX 50 (euro area), the CAC40 (France), the DAX (Germany), and the FTSE 100 (UK) during the period our dataset covers, we obtain average correlations between these indices of more than 96%. Thus, the volatility indices in different countries and currencies seem to be comparable, and therefore, we include the volatility index of the EURO STOXX 50 (V2X) on a weekly basis for all covered bonds in our dataset and call the variable *volatility*. Next, we include one variable with regard to the currency. Public covered bonds are issued in various currencies with the majority being issued in euros, as mentioned in Section 3.2.2. In different currency areas, a central bank governs the interest rate level to control inflation, implying increasing interest rates when inflation is too high. Simultaneously, higher inflation means that (nominal) debt is worth less in the future and, therefore, that default rates of corporations should decrease. Furthermore, an increase in the interest rate level leads to an increase in a corporation's expected asset-value growth rate and, thus, decreasing default rates, leading to lower risk premiums.[77] Summarized, the risk premium of a corporate bond should be a decreasing function of the risk-free rate of interest, as already stated by Merton (1974). We also expect this to hold for public covered bonds, which is in line with the literature on mortgage covered bonds and the German Pfandbrief market.[78] Therefore, we include the six-month LIBOR to reflect the current interest rate level. We obtain the quotes in percentage points on a weekly basis. Because no LIBOR quotes exist for the Norwegian krone (NOK), we use the NIBOR (Norwegian Interbank Offered Rate) instead. Nevertheless, we call the variable *LIBOR*.

All of the following variables are country-specific. On a weekly basis, we can only include two variables reflecting the capital market. First, we obtain the quotations of the benchmark stock indices, calculate the return over the preceding 52 weeks, and call the variable *stock index return*. Stock indices reflect investors' expectations about future earnings of the companies; the development of the stock market in a country can be considered a leading indicator of the future development of the country's economy. For example, the S&P 500 index is part of the 'Conference Board Leading Economic Index'[79] for the U.S. An increase in the stock index describes positive expectations about the future and should therefore lead to a decrease in risk premiums. Second, we include the swap spreads of the government bonds with a maturity of five years and call this variable *government spread*. The risk premium of a country's government bond can also be considered a leading indicator of the future development of a country's economy. The risk premium of a U.S. government bond,[80] for instance, is likewise part of the 'Conference Board Leading Economic Index'. This variable has several functions. First, an increase in this risk premium reflects negative expectations for the future economic situation and should therefore lead to an increase in covered bond risk premiums. Second, the risk premium of a government bond covers possibly unobservable factors affecting the entire interest-bearing security market. Third, and most important with regard to public

[77] See Van Landschoot (2008).
[78] See Prokopczuk and Vonhoff (2012); Rees (2001).
[79] More information about this index and the Conference Board can be found at http://www.conference-board.org/data/bcicountry.cfm?cid=1. Accessed: 22 March 2018.
[80] This risk premium is calculated as the difference between the yield to maturity of a U.S. treasury bond with a maturity of ten years and the federal funds rate.

covered bonds, this risk premium can be seen as a proxy of the quality of the cover pools often consisting mainly of loans to LRGs. Unfortunately, for Luxembourg, no historical data for a generic five-year government bond are available. However, the ECB at least provides an indication of the yield to maturity of a government bond with a maturity of ten years on a monthly basis. We subtract the ten-year swap rate of this yield to calculate the risk premium. Because observations from Luxembourg account for less than 6% of the dataset, the effects should be small.

The following variables are not directly related to the capital market but instead describe the macroeconomic situation in a country. First, along with the two leading economic indicators *stock index return* and *government spread*, we include the *unemployment rate*. The unemployment rate in a country can be used to describe the country's current economic situation. The unemployment rates of the 50 states of the U.S., for example, are part of the 'Federal Reserve Bank of Philadelphia State Coincident Indices'. A high unemployment rate reflects a weak economic situation and should therefore lead to high risk premiums. This variable is obtained from Thomson Reuters Advanced Analytics for all countries and changes quarterly. We further include the government debt-to-GDP ratio and the house price index, which also change quarterly. The first variable is obtained from Eurostat for the majority of countries and from Thomson Reuters Advanced Analytics for the remaining ones. The government debt-to-GDP ratio describes the financial weakness of public sector entities in a country. Therefore, it can be used to approximate the value of loans awarded to them and thus, it serves as another proxy for the quality of the cover pools. An increase in this ratio indicates an increase in the default risk of possible cover assets and should therefore lead to an increase in risk premiums of public covered bonds. Regarding the absolute height of this ratio, there have always been marked differences in different countries, but for a long time, even for countries with a high ratio, investors often assigned nearly no default risk to the related government bonds. Even for countries in the European Union, in which there exist rules to restrict this ratio (the Maastricht criteria, which set 60% as an upper limit), many countries violate these criteria without fearing drastic sanctions. Therefore, they have no real incentive to lower this ratio, and the absolute height of the ratio can be considered a country fixed effect, that is already priced into investments from these countries. However, a drastic change in this ratio would mean a significant change in the current financial strength of the public sector in a country and could therefore lead to a reaction on the part of investors. To facilitate estimating the effects of such changes, we calculate the difference compared with the value in the same quarter of the previous year and call the new variable *debt-GDP-ratio difference*. The house price index is obtained from the International House Price Database provided by the 'Federal Reserve Bank of Dallas' for all but two countries;[81] for Austria, we obtain the data from the National Bank of Austria, and for Portugal from the ECB. As mentioned in the explanation of research question 2, a house price index describes a part of the macroeconomic environment in a country and can further be used to approximate the quality of the issuing banks' balance sheets. Therefore, we expect risk premiums of public covered bonds to decrease when house prices increase. We calculate the percentage change of the index over the preceding four quarters and call the obtained variable *house price index change*.

Finally, we include the relative share of the sum of local and state government debt in the entire government debt in a country and call this variable *non-central government debt*. As mentioned in Section 3.2.1, a large share of the loans within a cover pool is granted to LRGs and not directly to the central government. By including this variable, we account for two facts. First, in countries with a high percentage of non-central government debt, diversification with regard to different debtors within a cover pool might be higher. Second, the higher this value, the more important might be public covered bonds in a country due to the limited access of LRGs to the capital market and the corresponding strong dependence of LRGs on financial institutions to borrow money. Thus, we expect a high percentage of non-central government debt to lead to lower risk premiums of public covered bonds.

[81] A detailed description of the data can be found in Mack and Martínez-García (2011).

3.3.2.3 Event Variables

Finally, to be able to analyze the effect of exogenous events, we include dummy variables for different periods. As mentioned in Section 3.2.2, we expect the financial crisis following the collapse of Lehman Brothers and the sovereign debt crisis to have an effect on risk premiums of public covered bonds, and therefore, for both crises, we include one dummy each, named *financial crisis* and *sovereign debt crisis*, respectively:

$$\text{Financial Crisis} = \begin{cases} 1, & \text{if 10 October 2008} \leq \text{date} \leq \text{08 October 2009}, \\ 0, & \text{otherwise}, \end{cases} \tag{3.1}$$

$$\text{Sovereign Debt Crisis} = \begin{cases} 1, & \text{if 09 October 2009} \leq \text{date} \\ & \quad \leq \text{28 December 2012}, \\ 0, & \text{otherwise}. \end{cases} \tag{3.2}$$

Naturally, it is difficult to specify an exact date when the financial crisis started and when it 'turned into' the sovereign debt crisis. Although it seems reasonable to assign the beginning of the financial crisis to the time around the collapse of Lehman Brothers, the end of this period and the start of the sovereign debt crisis are more difficult to determine. We use the threshold regression method developed by Hansen (1999) to determine the time borders. Hansen (1999) developed the threshold regression for balanced panels but our panel is unbalanced. However, the basic idea is to perform the within-transformation and then minimize the error sum of squares, which is equivalent to maximizing the R^2 within in a fixed effects estimation.[82] This concept can be transferred to the unbalanced case. Therefore, we estimate

$$spread_{i,t} = \beta_0 + \beta_1 \cdot 1_{[\tau_1 \leq t < \tau_2]} + \beta_2 \cdot 1_{[\tau_2 \leq t]} + \gamma' \cdot X_{i,t} + u_{i,t} \tag{3.3}$$

[82]See Section 3.6.1.1 in this chapter's appendix for a short explanation of the fixed effects estimation.

using fixed effects estimation for different combinations of parameters τ_1 and τ_2 that fulfill the restriction that each period lasts at least one year (i.e., 52 weeks). Here, index i represents the covered bond and index t represents time. $1_{[\cdot]}$ is the indicator function, which is one if the expression in square brackets is true and zero otherwise. $X_{i,t}$ are time-varying bond-specific controls (bond rating and bid-ask-spread). Because we want to determine different economic environments, we leave out macroeconomic controls. We perform the analysis for all 21,945 possible combinations of τ_1 and τ_2. The highest R^2 within equals 0.466 and results from the parameter combination presented in equations 3.1 and 3.2. Thus, the beginning of the financial crisis period is not assigned to the date of the collapse of Lehman Brothers. The determined date is reasonable nevertheless, because in the week prior to this date, there were dramatic turbulences in the international capital markets showing the increased panic of investors. The Dow Jones Industrial Average decreased by more than 18%, for example. Regarding the end of the financial crisis and thus, the beginning of the sovereign debt crisis, October 2009 seems rather early. However, as shown by Will and Kwon (2010), in the fall of 2009, average risk premiums of covered bonds in several countries started moving sideways after a having reached peaks in the spring of 2009 during the financial crisis. Moreover, they show that covered bond issuance increased strongly around that time after very low supply during the previous months. These two facts indicate the market participants' impression of having overcome the worst of the financial crisis. Furthermore, at the beginning of October 2009, Greece elected a new parliament, and shortly afterward, the new government had to rectify the country's fiscal deficit for that year, which can indeed be seen as the beginning of the sovereign debt crisis. We also performed the analysis for each subsample we will investigate in Section 3.4.3. In one subsample, the borders are shifted by one week, in the other subsamples, the borders are equal to those obtained for the entire dataset. Thus, we conclude that the different markets enter into the financial crisis and out of it at the same time.

To highlight the benefit of determining the borders between different periods with this methodology, we also estimate equation 3.3 with values for τ_1 and τ_2 derived from the literature. Using the collapse of Lehman Brothers as the starting point of the financial crisis and July 2010 as the beginning of the sovereign debt crisis, as Prokopczuk et al.

(2013) do, the R^2 within equals 0.426 and is, thus, considerably lower than the R^2 within obtained with our crises variables (0.466). Changing the starting point of the financial crisis to May 2007, as Prokopczuk and Vonhoff (2012) do, even reduces the R^2 within to only 0.276.

Concerning the covered bond purchase programs, we construct two dummy variables for each program. The first dummy variables only indicate the periods of the respective programs and are named *CBPP1* and *CBPP2*. The second dummy variables are further restricted to covered bonds eligible to be purchased from the ECB during the particular programs and are named *CBPP1_restricted* and *CBPP2_restricted*, respectively. They are defined as follows:

$$\text{CBPP1} = \begin{cases} 1, & \text{if 07 May 2009} \leq \text{date} \leq \text{30 June 2010,} \\ 0, & \text{otherwise,} \end{cases} \tag{3.4}$$

$$\text{CBPP1\_restricted} = \begin{cases} 1, & \text{if CBPP1} = 1\text{, euro-denominated,} \\ & \text{issued in the euro area,} \\ 0, & \text{otherwise,} \end{cases} \tag{3.5}$$

$$\text{CBPP2} = \begin{cases} 1, & \text{if 06 October 2011} \leq \text{date} \leq \text{31 October 2012,} \\ 0, & \text{otherwise,} \end{cases} \tag{3.6}$$

$$\text{CBPP2\_restricted} = \begin{cases} 1, & \text{if CBPP2} = 1\text{, euro-denominated, issued} \\ & \text{in the euro area, min. BBB-rating,} \\ & \text{issue volume} \geq 300 \text{ million EUR,} \\ & \text{term to maturity} \leq 10.5 \text{ years,} \\ 0, & \text{otherwise.} \end{cases} \tag{3.7}$$

Because minimum requirements with regard to the rating and the issue size were only set 'as a rule'[83] for the first purchase program, we do not include these requirements in

[83] See ECB (2010).

CBPP1_restricted. An overview of the set of variables used in our analyses is shown in Table 3.1.

Table 3.1: **Variable Overview.**
This table gives an overview about the different variables used in our analyses.

Variable	Description
Dependent Variable	
Asset Swap Spread	Asset swap spread in basis points
Covered Bond-specific	
Coupon	Coupon in percentage points
Logvolume	Logarithm of the issue size
Maturity	Maturity in years
AA	Dummy for AA-rating
A/BBB	Dummy for A- or BBB-rating
Term to Maturity	Term to maturity in years
Bid-Ask-Spread	Difference between ask and bid price
Macroeconomic	
Volatility	Implied volatility index of the EURO STOXX 50
LIBOR	LIBOR-rate in percentage points
Stock Index Return	Percentage change of the benchmark stock index in a country (e.g., DAX for Germany, Dow Jones Industrial Average for the U.S.) in previous 52 weeks
Government Spread	Swap spread of a five-year-government bond
Unemployment Rate	Unemployment rate in percentage points
Debt-GDP-Ratio Difference	Change of government debt-GDP-ratio in the previous four quarters
House Price Index Change	Percentage change of the house price index in the previous four quarters
Non-Central Government Debt	Percentage of non-central government debt in the entire government debt
Event Dummies	
Financial Crisis	Dummy for the financial crisis following the collapse of Lehman Brothers
Sovereign Debt Crisis	Dummy for the sovereign debt crisis
CBPP1	Dummy for the first covered bond purchase program
CBPP1__restricted	Dummy for the first covered bond purchase program and covered bond must be eligible
CBPP2	Dummy for the second covered bond purchase program
CBPP2__restricted	Dummy for the second covered bond purchase program and covered bond must be eligible

3.3.3 Descriptive Statistics

Table 3.2: **Summary Statistics: Covered Bond-specific Dummy Variables.**
This table presents an overview of several covered bond-specific dummy variables.

	Bonds	Percent	Cum.	Obs.	Percent	Cum.
Currency						
AUD	3	0.54	0.54	889	1.23	1.23
CAD	2	0.36	0.89	191	0.26	1.49
CHF	23	4.11	5.00	3,795	5.23	6.72
EUR	462	82.50	87.50	56,767	78.23	84.94
GBP	12	2.14	89.64	2,458	3.39	88.33
JPY	7	1.25	90.89	1,446	1.99	90.32
NOK	1	0.18	91.07	35	0.05	90.37
USD	50	8.93	100.00	6,986	9.63	100.00
Total	560	100		72,567	100	
Country						
Austria	29	5.18	5.18	4,006	5.52	5.52
France	86	15.36	20.54	15,582	21.47	26.99
Germany	364	65.00	85.54	38,980	53.72	80.71
Ireland	26	4.64	90.18	4,883	6.73	87.44
Italy	5	0.89	91.07	912	1.26	88.69
Luxembourg	27	4.82	95.89	4,227	5.82	94.52
Norway	1	0.18	96.07	35	0.05	94.57
Portugal	1	0.18	96.25	180	0.25	94.82
Spain	17	3.04	99.29	3,005	4.14	98.96
United Kingdom	4	0.71	100.00	757	1.04	100.00
Total	560	100		72,567	100	
Rating						
AAA	—	—	—	66,635	91.83	91.83
AA	—	—	—	5,125	7.06	98.89
A/BBB	—	—	—	807	1.11	100.00
Total	—	—	—	72,567	100.00	

Table 3.2 presents summary statistics for covered bond-specific dummy variables. A large portion of the public covered bonds are denominated in euros. This is in line with statistics about the global covered-bond market in ECBC (2014). The second- and third-most important currencies are the U.S. dollar and the Swiss franc, respectively. Altogether, approximately 96% are issued in these three currencies. Most public covered bonds are issued in Germany, followed by France and Luxembourg. As expected, an AAA-rating is assigned to the vast majority of observations, which is in line with Packer et al. (2007). However, the variety of the ratings increased over time. Although in 2006 – 2009, nearly every bond had an AAA- or AA-rating, this changed significantly in subsequent years,

resulting in only 60% achieving AAA-ratings in 2012. Differences between the years in the observed period are also observable in the distribution of the observations of the countries. There are not always observations in every year in every country. According to ECBC (2014), for example, the first public covered bonds in Portugal were issued in 2008, and thus, there can be no observations of Portuguese covered bonds in the previous years.

Table 3.3: **Summary Statistics: Covered Bond-specific Variables.**
This table reports summary statistics for the asset swap spread, for several further time-varying covered bond-specific variables on the observation level, and for time-constant covered bond-specific variables on the bond level.

Variable	N	mean	sd	min	p25	p50	p75	max
Asset Swap Spread (bp)	72,567	38.9	83.7	-50.6	-7.6	3.8	50.8	984.3
Bid-Ask-Spread (%)	72,567	0.27	0.49	0.00	0.05	0.15	0.30	11.67
Term to Maturity (years)	72,567	4.32	3.33	1	2.07	3.43	5.55	30.02
Maturity (years)	560	6.57	3.63	1.04	4.00	5.25	10.01	30.02
Volume (millions of euros)	560	1,099	790.70	250	500	1,000	1,500	5,000
Logvolume	560	20.57	0.72	19.34	20.03	20.72	21.13	22.33
Coupon (%)	560	3.65	1.20	0.125	2.75	3.75	4.625	6

Table 3.3 presents summary statistics of the asset swap spread and other covered bond-specific variables. Apparently, there exists heavy variation in risk premiums with a span of 1,035 bp, although the majority is at a rather low level, as seen in the third quartile, which is ‘only’ 50.8 bp. Concerning the bid-ask-spread, similar statements hold. Again, most of the variation stems from observations above the third quartile; the magnitude is even more distinct. The average maturity is medium-term, with a mean of 6.57 years and a median of 5.25 years. By construction, the term to maturity is slightly lower because it decreases over time. The volume is presented in millions of euros; however, the logarithmized variable has been calculated using the original values. The mean issue size is nearly €1.1bn, and once again, a steep increase after the third quartile can be recognized. The median issue size is €1bn, and thus, approximately half of our sample consists of non-jumbo public covered bonds. Finally, the coupon rates are presented. They range between 0.125% and 6%, with a mean of 3.65%.

Table 3.4: **Summary Statistics: Asset Swap Spreads in Different Countries.** This table reports summary statistics for the dependent variable asset swap spread (in bp) on a country level.

Country	mean	sd	min	p25	p50	p75	max
Austria	37.6	41.3	-23.2	-0.6	34.9	58.9	202.8
France	61.5	74.1	-29.4	-0.8	43.0	100.1	320.6
Germany	5.9	30.9	-50.6	-10.1	-3.9	11.6	175.2
Ireland	132.0	154.5	-33.1	-3.7	61.8	264.6	575.3
Italy	79.4	99.7	-37.8	3.1	36.3	115.0	355.7
Luxembourg	75.4	109.2	-27.7	-5.2	24.0	138.4	565.6
Norway	67.5	16.8	41.7	50.1	67.6	84.2	91.8
Portugal	413.2	278.7	43.9	224.0	366.6	547.7	984.3
Spain	104.5	120.6	-22.8	7.4	59.2	177.8	547.0
United Kingdom	80.4	83.0	-10.8	15.7	65.7	121.4	396.6
Total	38.9	83.7	-50.6	-7.6	3.8	50.8	984.3

Much of the heterogeneity in the asset swap spreads stems from differences between the countries, as seen in Table 3.4. The mean asset swap spreads range from 6 bp in Germany to almost 413 bp in Portugal. In addition to Portugal, the highest average asset swap spreads can be observed in the other countries directly affected by the sovereign debt crisis, namely, Ireland, Italy and Spain as well as the UK.

Table 3.5: **Summary Statistics: Number of Issuers in Different Countries and Periods.** This table reports the number of different issuers in each country in the entire dataset and in the three different time periods pre-crisis, financial crisis, and sovereign debt crisis.

Country	Entire Sample	Pre-Crisis	Financial Crisis	Sovereign Debt Crisis
Austria	6	2	2	6
France	11	7	8	9
Germany	34	32	25	26
Ireland	3	3	2	2
Italy	2	1	1	2
Luxembourg	6	5	5	6
Norway	1	0	0	1
Portugal	1	0	1	1
Spain	7	7	5	5
United Kingdom	3	2	2	3
Total	74	59	51	61

The number of issuers in the different countries is presented in Table 3.5. Overall, there are 74 different issuers in the dataset. Regarding the distribution between the countries, analogous statements as with regard to the number of bonds hold. Most issuers come from Germany, followed by France. Notably, in every country (except Norway and Portugal, in which there is only one bond each), there exist multiple issuers. Thus, in no country the entire public covered-bond market is dominated by just one financial institution. In Section 3.2.1, we referred to 46 issuers of public covered bonds mentioned in Nord/LB (2016). In our dataset there are more issuers because, on the one hand, we did not restrict our sample to a minimum volume of €500 million, and, on the other hand, some issuers in our dataset no longer actively issue public covered bonds.

3.4 Empirical Results

In this section, we perform various empirical regression analyses. The dependent variable is always the asset swap spread. Since we work with panel data, we use panel data estimation techniques to determine the effects of the previously described variables on risk premiums of public covered bonds. We are the first study investigating the factors influencing covered bond risk premiums using panel data estimation techniques leading to unbiased results. The rest of this section is organized as follows. First, we analyze the fraction of the variance that can be explained by time-constant covered bond-specific and time-varying country- and currency-specific variables in a preliminary analysis. Subsequently, we examine what covered bond-specific factors influence risk premiums and in the main analysis, we consider the influence of macroeconomic factors and exogenous events.

3.4.1 Preliminary Analysis

In general, we explain the factors influencing risk premiums of public covered bonds. Apparently, possible influencing factors can vary between covered bonds and over time

($X_{i,t}$), only between covered bonds (Y_i), or only over time (Z_t). Thus, we assume a model of the following form:

$$spread_{i,t} = \beta' \cdot X_{i,t} + \gamma' \cdot Y_i + \delta' \cdot Z_t + u_{i,t}. \tag{3.8}$$

In a preliminary analysis, we determine how much of the variance in the data can be explained by the country, the currency, the issuer, other bond fixed effects, and time dummy variables. We therefore perform pooled OLS estimations with different combinations of these factors as independent variables. Although our dataset consists of weekly observations, we include quarter dummies because many of the possible influencing factors, which we will examine later, only change quarterly. The results of these analyses are presented in Table 3.6.[84]

Table 3.6: **Preliminary Analysis.**
This table reports coefficients of determination of pooled OLS estimations of the influence of several dummy variables on risk premiums (in bp).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Country FE	Yes	Yes								
Currency FE		Yes								
Bond FE			Yes	Yes				Yes	Yes	Yes
Quarter FE				Yes						
Country#Quarter FE					Yes			Yes		Yes
Currency#Quarter FE						Yes				Yes
Issuer#Quarter FE							Yes		Yes	
Observations	72,567	72,567	72,567	72,567	72,567	72,567	72,567	72,567	72,567	72,567
Independent Variables	9	15	559	586	240	191	1,329	790	1,811	942
R^2	0.275	0.293	0.484	0.697	0.786	0.518	0.867	0.874	0.910	0.898
adj. R^2	0.274	0.292	0.480	0.695	0.785	0.517	0.864	0.872	0.908	0.897

Country fixed effects account for more than 27% of the variance. Adding currency fixed effects only increases this fraction to 29%,[85] but when using only bond fixed effects instead, almost half of the variance can be explained. Furthermore, including quarter dummies increases the adjusted R^2 to nearly 70%. Therefore, bond fixed effects and

[84] We also present the number of independent variables in the different estimations. The maximum number is 1,811, and thus, overfitting is no problem.

[85] The only covered bonds issued in NOK are issued in Norway. There are no Norwegian covered bonds issued in another currency in our dataset. Therefore, the Norway dummy and the NOK dummy are the same. For all other currencies, there are covered bonds issued in more than one country, and thus, the corresponding currency dummies can be included in the analysis.

time effects already explain a large portion of the variance in the data. The coefficient of determination can be increased even more by interacting the country dummies with the quarter dummies, leading to an adjusted R^2 of 78.5%. Interacting currency dummies with quarter dummies instead leads to an adjusted R^2 of less than 52%. However, there is less variation in the dataset with regard to the currency than with regard to the country as has been shown in Table 3.2, and therefore, the R^2 nevertheless shows that the currency is an important factor influencing risk premiums. Interacting issuer dummies with quarter dummies increases the adjusted R^2 to more than 86%. However, investigating bond fixed effects together with country dummies interacted with quarter dummies results in an even higher adjusted R^2 of above 87%, as shown in column (8). This value can be increased to nearly 91% by investigating the effects of bond fixed effects together with issuer fixed effects interacted with quarter dummies in column (9). However, the number of independent variables is more than twice as big as that in column (8). Adding currency fixed effects interacted with quarter dummies to the model in column (8) only leads to a small increase in the explained amount of variance. Overall, covered bond-specific variables and time-varying country-specific variables as well as the currency have a significant influence on risk premiums of public covered bonds. The importance of country-specific factors is in line with our expectations since we expected public covered bonds to react to macroeconomic developments due to loans to public sector entities being the collateral, as discussed prior to research question 2. Thus, our choice of many possible country-specific macroeconomic influencing factors in the dataset is supported by the preliminary analysis.

3.4.2 Effect of Covered Bond-specific Factors

In this section, we focus on covered bond-specific factors possibly influencing risk premiums. Thereby, we will be able to investigate research question 1 in more detail.

As shown in the previous subsection, most of the variance can be explained by country fixed effects interacted with quarter dummies together with bond fixed effects. To examine the influencing factors in more detail, we split up the bond fixed effects into different time-constant covered bond-specific factors and further include time-varying covered bond-specific factors. To estimate the effect of time-constant variables in a panel dataset, random effects or pooled OLS can be applied. To choose which of these methods is appropriate, we perform the Lagrange-multiplier test, which was invented by Breusch and Pagan (1980), in the modified version developed by Baltagi and Li (1990), which indicates that random effects estimation is appropriate.[86] Thus, we estimate the effects by random effects while controlling for country-specific time effects and the currency.[87] We further interact each bond-specific variable with the two crisis dummies to investigate changes in the effects of bond-specific variables in different time periods. Thereby, we can also investigate research question 3.1 in more detail. Finally, as shown in the preliminary analysis, the issuer can be an important factor. Thus, we include issuer fixed effects to account for differences between issuers. The results are shown in Table 3.7.[88]

Concerning the pre-crisis period, the effects of the rating dummies are not significant, showing the high confidence in this asset class by investors prior to the recent economic crises, particularly because the share of German Pfandbriefe was high during this period. Term to maturity and logvolume are significant but only term to maturity has the expected sign. The longer the term to maturity is, the higher is the risk premium. The effect of logvolume is surprisingly positive. All other variables are insignificant. However, this changes when examining the coefficients of the financial crisis dummy and of the corresponding interaction terms. The pure time dummy is significant and the coefficient

[86]See Section 3.6.1.2 in this chapter's appendix for a short explanation of the random effects estimation and Section 3.6.2.1 for a short description of the Breusch/Pagan test.

[87]The standard method to investigate panel data is to perform fixed effects regressions. While effects of time-constant variables cannot be estimated using fixed effects, this method always produces consistent estimates for time-varying variables. For our data, however, both fixed and random effects estimation lead to similar results concerning time-varying variables and thus, using random effects regressions seems reasonable to estimate effects of both time-varying and time-constant variables in the present section. To be more specific, when comparing the estimated coefficients of time-varying variables obtained by fixed and random effects for the complete model presented in Section 3.4.3, apart from two insignificant coefficients, all coefficients have the same sign and are of similar magnitude. Furthermore, 13 of the 17 coefficients of time-varying variables estimated by random effects are even contained in the 95% confidence interval of the corresponding estimate obtained by the fixed effects regression. Therefore, using random effects estimation to investigate the effects of both time-constant and time-varying variables is reasonable nonetheless and therefore, we use random effects estimation in the present section.

[88]See Section 3.6.3 in this chapter's appendix for a short description of the three different coefficients of determination presented in the following table.

Table 3.7: **Effect of Covered Bond-specific Variables on Risk Premiums.** This table reports random-effects estimates of covered bond-specific variables on risk premiums (in bp). The base rating is AAA. Standard errors shown in parentheses are Huber/White standard errors and therefore robust to heteroscedasticity. The symbols *, **, and *** indicate statistical significance at the 5%, 1%, and 0.1% level, respectively.

	(1)
Coupon	-2.384
	(1.424)
Logvolume	3.114*
	(1.526)
AA	2.160
	(3.130)
A/BBB	-1.118
	(7.415)
Maturity	0.369
	(0.487)
Term to Maturity	1.191*
	(0.498)
Bid-Ask-Spread	-20.60
	(11.70)
Financial Crisis	353.4**
	(118.8)
...#Coupon	11.27*
	(5.300)
...#Logvolume	-16.78**
	(5.873)
...#AA	64.41***
	(13.28)
...#Maturity	-1.551
	(1.751)
...#Term to Maturity	-0.763
	(1.732)
...#Bid-Ask-Spread	48.59*
	(23.59)
Sovereign Debt Crisis	330.2***
	(89.61)
...#Coupon	7.852**
	(2.922)
...#Logvolume	-16.11***
	(4.504)
...#AA	15.02**
	(5.482)
...#A/BBB	42.05**
	(16.25)
...#Maturity	-0.336
	(0.898)
...#Term to Maturity	1.668
	(1.074)
...#Bid-Ask-Spread	46.51***
	(12.10)
Constant	-19.97
	(29.53)
Country#Quarter FE	Yes
Currency FE	Yes
Issuer FE	Yes
Observations	72,567
R^2 within	0.7868
R^2 between	0.8964
R^2 overall	0.8430

is very distinct, showing markedly higher risk premiums during this period. Furthermore, the coefficient of the interaction with the coupon is significant with the expected sign. In contrast to the pre-crisis period, there is also a considerably higher risk premium for AA-rated compared to AAA-rated public covered bonds.[89] Moreover, investors seem to focus more on liquidity because the effects of logvolume and the bid-ask-spread are significant during the financial crisis and have the expected sign. However, when interpreting the effect of the estimates, one must keep in mind that the bid-ask-spread is far below one in the vast majority of cases; therefore, the actual effect is less pronounced than it appears at first glance. During the sovereign debt crisis, results are similar to those obtained during the financial crisis. The pure time dummy is again very distinct and significant and the interaction with the coupon is significant with the expected sign. Again, a worse rating leads to a higher risk premium although the additional effect is less pronounced than during the financial crisis, and interactions with logvolume and bid-ask-spread are still significant with similar magnitudes of the coefficients as before.

The included bond-specific variables have already been shown to influence risk premiums of mortgage covered bonds.[90] Because many of them are significant and because much of the variation in the data can be explained by our model, as shown by the high values of the coefficients of determination, the selection of bond-specific factors is also appropriate for public covered bonds. However, there are significant differences in the effects between non-crisis and crisis periods. Besides a general increase in risk premiums, liquidity seems to be particularly important during crisis periods.

3.4.3 Effect of Macroeconomic Factors and Events

In this section, we analyze what macroeconomic factors and exogenous events affect risk premiums of public covered bonds. Furthermore, we investigate international differences between public covered-bond markets. Thus, we will examine research questions 2, 3, and 4 in more detail. Because we work with panel data, fixed and random effects estimations

[89] During the financial crisis, there is no bond with an A- or BBB-rating in the sample. Thus, we cannot investigate the interaction effect of the financial crisis dummy and the A/BBB dummy in Table 3.7.
[90] See Prokopczuk and Vonhoff (2012).

are possible. In the last section, we performed random effects estimations because we were interested in possible influences of time-constant variables, which are not possible to analyze with fixed effects estimations. In this section, however, both methods are applicable. To decide which methodology should be applied, we perform the Hausman test. This test has consistency of both estimators and efficiency of the random effects estimator under the null hypothesis, and it has consistency only of the fixed effects estimator as the alternative.[91] Because time-constant variables cannot be included in a fixed effects estimation, the variables coupon, logvolume, and maturity are eliminated in this regression but are included in the random effects estimation. Furthermore, the interactions between the country dummies and the quarter dummies are dropped because we analyze the effect of other country-specific time-varying influencing factors. Instead, the macroeconomic and event variables are included. The Hausman test strongly rejects the hypothesis (p-value $< 0.1\%$); thus, fixed effects estimations will be performed in this section.[92] The results of these estimations are shown in Table 3.8.

Since we are interested in the effects of the macroeconomic variables and exogenous events, we include time-varying bond-specific variables and their interactions with the crisis dummies only as control variables and do not present the corresponding coefficients. In the first column, we investigate the entire dataset. Concerning the macroeconomic variables directly related to the capital market, only the coefficient of the stock index return is significant and has the expected sign. Concerning the other macroeconomic variables, the negative effect of the house price index change is highly significant, which is remarkable since we only investigate public covered bonds. Therefore, apart from serving as a proxy for the values of the cover pools of mortgage covered bonds in different countries, as proposed by Prokopczuk and Vonhoff (2012), due to its function as an indicator of the macroeconomic environment and as an indicator of the quality of the issuers' balance sheets, it also influences risk premiums of public covered bonds. However, compared to

[91] See Section 3.6.2.2 in this chapter's appendix for a short description of the Hausman test.

[92] The general idea of the Hausman test is to examine whether the differences in the estimated coefficients of the time-varying variables between fixed effects and random effects estimation are statistically significant. If they are, the null hypothesis is rejected, as is the case in our setting. Therefore, we apply fixed effects regressions in the present section. However, it has to be kept in mind that, although the differences in the coefficients are statistically significant, as the Hausman test indicates, they seem to be of small economic relevance, as shown by the extensive discussion in footnote 87.

Table 3.8: **Effect of Macroeconomic Factors and Events on Risk Premiums.** This table reports fixed-effects estimates of macroeconomic variables and exogenous event dummies on risk premiums (in bp). Bond-specific controls are the rating, the bid-ask-spread, and the term to maturity and they are interacted with the two crisis dummies. Standard errors shown in parentheses are Huber/White standard errors and therefore robust to heteroscedasticity. The symbols *, **, and *** indicate statistical significance at the 5%, 1%, and 0.1% level, respectively.

	(1)	(2)	(3)	(4)
Currency	All	Euro	Non-Euro	Non-Euro
Country	All	All	All	All
Volatility	-0.0222	-0.00109	-0.127	-0.133
	(0.0828)	(0.0882)	(0.212)	(0.212)
LIBOR	-2.138	-3.751***	-2.372	-3.052
	(1.367)	(0.818)	(2.985)	(2.926)
Stock Index Return	-0.544***	-0.477***	-0.431***	-0.468***
	(0.0569)	(0.0541)	(0.101)	(0.100)
Government Spread	10.26	12.01	-1.186	-1.489
	(5.829)	(7.290)	(2.948)	(2.733)
Unemployment Rate	5.643**	3.717*	10.77***	10.71***
	(1.871)	(1.691)	(2.129)	(2.054)
Debt-GDP-Ratio Difference	1.997***	1.600*	2.759**	2.687**
	(0.582)	(0.658)	(0.927)	(0.924)
House Price Index Change	-1.563***	-1.083***	-1.193*	-1.093
	(0.332)	(0.300)	(0.582)	(0.565)
Non-Central Government Debt	-2.339***	0.286	-2.505**	-2.854***
	(0.693)	(0.883)	(0.775)	(0.735)
Financial Crisis	36.88***	13.27	151.4***	148.6***
	(7.755)	(7.423)	(19.67)	(19.56)
Sovereign Debt Crisis	24.54***	-3.699	72.42***	68.44***
	(6.471)	(6.782)	(12.98)	(12.65)
CBPP1	5.804	-16.07***	-29.72***	-28.69***
	(7.322)	(2.711)	(7.887)	(7.934)
CBPP1_restricted	-29.06***			
	(7.628)			
CBPP2	44.00***	-8.255	58.11***	32.79***
	(9.269)	(10.83)	(8.155)	(6.970)
CBPP2_restricted	-24.99*	17.37		
	(9.976)	(10.23)		
CBPP2#PIIGS	-4.656	4.399	-13.91	14.84
	(9.483)	(10.20)	(13.69)	(12.82)
CBPP2#Dexia				92.40***
				(12.50)
Constant	22.38	-28.94	-53.54	-46.42
	(21.59)	(27.41)	(33.12)	(32.63)
Bond-Specific Controls	Yes	Yes	Yes	Yes
Observations	72,567	56,767	15,800	15,800
R^2 within	0.6405	0.6294	0.7570	0.7707
R^2 between	0.7642	0.7689	0.7383	0.7211
R^2 overall	0.6762	0.7104	0.6674	0.6596

the effect shown for mortgage covered bonds in the literature, the effect for public covered bonds is markedly smaller. Furthermore, the debt-GDP-ratio difference, which serves as a proxy for the values of the cover pools in the different countries, as well as the unemployment rate are significant with the expected signs. Increases of these variables lead to an increase of risk premiums. Non-central government debt, on the other hand, has a highly significant negative effect, as expected. Overall, country-specific macroeconomic variables are important factors influencing risk premiums of public covered bonds, which is in line with our expectations and which is reasonable since public covered bonds are important refinancing tools for banks providing loans to public sector entities.

The two crisis dummies both have a significant positive effect on risk premiums. Compared to Table 3.7, however, the effects are markedly smaller, showing that large parts of the high effects of the two crises on risk premiums shown in the previous subsection are already incorporated in the effects of the macroeconomic variables. Finally, when examining the effects of the two covered bond purchase programs by the ECB, we see that the coefficient of the pure time dummy of the first purchase program is not statistically significant. When restricting this time dummy to covered bonds eligible for being purchased during the program, we see a highly significant negative effect of more than 29bp and, thus, the program lowered risk premiums of such public covered bonds. Regarding the second program, the pure time dummy has a significant positive effect, whereas the restricted dummy has a significant negative effect. However, the sum of the coefficients is positive, and applying a Wald test shows that the combined effect is highly significant (p-value $< 0.1\%$). Thus, we cannot conclude a decreasing effect of the second purchase program on risk premiums of public covered bonds. Because the second purchase program was conducted during the sovereign debt crisis, there might be differences of the effect for public covered bonds issued in crisis- and non-crisis-countries. Therefore, we further interact the corresponding dummy with a dummy for public covered bonds in the PIIGS-countries.[93] However, the effect is not statistically significant indicating no differences in the effect of the second purchase program between different countries. Since the overall

[93]The PIIGS-countries are Portgual, Ireland, Italy, Greece, and Spain. Since there are no Greek bonds in our dataset, the dummy actually would have to be called PIIS, but for didactic reasons we call it PIIGS.

effect of the second purchase program seems to be positive, we want to try to investigate reasons for this odd positive effect in the following.

As shown in the preliminary analysis, the currencies the covered bonds are issued in can be an important factor influencing risk premiums. Furthermore, because during the two purchase programs only euro-denominated covered bonds were eligible for purchase, influencing factors might differ between public covered bonds denominated in different currencies. Since furthermore, in the literature mainly euro-denominated covered bonds have been investigated heretofore, we split our dataset with regard to the currency. In column (2) of Table 3.8, we examine euro-denominated public covered bonds, and in column (3), we examine bonds issued in other currencies. Some of the effects of the variables are comparable, others differ considerably, however. Concerning the macroeconomic variables, the effects of the stock index return, the unemployment rate, the debt-GDP-ratio difference, and the house price index change are significant with the expected signs in both subsamples. However, the effect of LIBOR is only significant in column (2), whereas the effect of non-central government debt is only significant for non-euro-denominated bonds. The strongest differences can be seen in the effects of exogenous events. The increasing effects of the two crisis periods are very strong for covered bonds issued in other currencies than euro. For euro-denominated public covered bonds, on the other hand, the coefficients of the crisis dummies are even insignificant. Thus, the effects of the two crises are completely incorporated in the effects of the macroeconomic variables and in the interaction terms with the bond-specific controls. Therefore, due to the higher share of euro-denominated covered bonds in the entire dataset, the effects of the two crises have been underestimated for non-euro-denominated covered bonds and overestimated for euro-denominated covered bonds in column (1). This has implications for the effects of the two purchase programs because these programs were conducted during the crisis periods. In column (2), it can be seen that for euro-denominated covered bonds, the effect of the first purchase program is still negative and significant but that the absolute value is lower in this setting.[94] Regarding the second program, CBPP2 and CBPP2_restricted

[94] We excluded CBPP1_restricted from the analysis because there was only one euro-denominated covered bond that did not fulfill the ECB's criteria for being purchased during CBPP1.

no longer have a significant effect,[95] and the interactions term with the PIIGS dummy remains insignificant. In column (3), it can be seen that CBPP1 is now also negative and significant for covered bonds issued in other currencies. This shows that even if these covered bonds could not be purchased by the ECB, there was a recovery of the entire international public covered-bond market following the ECB's decision to implement the program. Concerning the second program, however, the effect is positive, highly significant and very strong but the interaction term with the PIIGS dummy is still insignificant. Thus, the second program did not lead to lower risk premiums for non-euro-denominated public covered bonds. However, almost 22% of observations during the time period of CBPP2 belong to public covered bonds issued by 'Dexia Municipal Agency', a subsidiary of 'Dexia S.A.', which was later renamed to 'Caisse Française de Financement Local'. On 10 October 2011, i.e., four days after the announcement of CBPP2, Dexia S.A. announced a restructuring. As a result of this, Dexia Municipal Agency was sold in January 2013. Thus, there was a high uncertainty regarding the future of Dexia Municipal Agency during the entire time period of CBPP2. Therefore, the strong positive effect of the belonging dummy might at least partly be driven by high risk premiums of covered bonds issued by Dexia Municipal Agency. Therefore, we interact the time dummy with a dummy for all public covered bonds issued by this institution. The results are presented in column (4) of Table 3.8. The coefficient of the interaction term is very high with a value of 92bp, showing the high risk premiums of bonds issued by Dexia Municipal Agency during the time of the restructuring. However, the dummy for the second program is also still positive and significant, showing an increase in risk premiums of other non-euro-denominated public covered bonds during this time period, although the effect is less pronounced than in column (3). Possible explanations could be that, since non-euro-denominated covered bonds were not eligible for being purchased by the ECB and, as mentioned prior to research question 4, since they only play a minor part in the international covered-bond market, investors might have preferred euro-denominated covered bonds because there was a higher demand in this market during this time period.

[95] Due to the more restrictive requirements on eligible covered bonds described in equation 3.7, there are eight euro-denominated covered bonds in our dataset that do not fulfill these criteria, and therefore, we can keep CBPP2_restricted.

Besides the currency, in the preliminary analysis, we further showed that the country a covered bond is issued in influences risk premiums. This is a reasonable assumption since the loans to public sector entities contained in the cover pools are most often granted to domestic debtors. Although we try to account for this using several country-specific variables, it might be useful to further split the dataset with regard to the country. Because covered bonds from Germany constitute the majority of the dataset, because of the international public covered-bond market, German public Pfandbriefe have been investigated in most detail, and because German BUNDs have been seen as safe-haven investments during recent crisis periods, we further split the euro-denominated covered bonds into covered bonds from Germany and other covered bonds. The results are shown in columns (1) and (2) of Table 3.9.[96]

Regarding the crisis dummies, similar to the findings in column (2) of Table 3.8, no significant effect can be observed for countries other than Germany. Thus, the effects of the two crises are completely incorporated in the effects of the macroeconomic and bond-specific variables. In Germany, however, the coefficient of the financial crisis dummy is positive and significant. A possible explanation for this different effect compared to public covered bonds issued in other countries might be that German macroeconomic variables reacted less strongly to the occurrence of the crisis than those in other countries. Concerning the monetary policy measures by the ECB, CBPP1 had a decreasing effect in both subsamples. For the second purchase program, however, a negative effect can only be observed for public covered bonds issued in Germany. For the non-German subsample, we again interact CBPP2 with a dummy for bonds issued by Dexia Municipal Agency because these account for more than 28% of the observations during the period of CBPP2.[97] Analogous to the effect shown for the non-euro dataset in column (4) of Table 3.8, we see a strong positive and highly significant effect. This shows that also euro-denominated bonds issued by Dexia Municipal Agency exhibited very high risk premiums during this

[96] As mentioned in footnote 95, there are only eight euro-denominated bonds not fulfilling the criteria for being purchased by the ECB during CBPP2. When further splitting the sample, there are only four of these bonds in each subsample and, thus, we do not include CBPP2_restricted in the following analyses.

[97] There are five additional observations of a bond issued by Dexia LdG Banque in Luxembourg. Since this bank is also part of the Dexia group, we also incorporate these observations in the Dexia dummy.

Table 3.9: **Effect of Macroeconomic Factors and Events on Risk Premiums.** This table reports fixed-effects estimates of macroeconomic variables and exogenous event dummies on risk premiums (in bp). Bond-specific controls are the rating, the bid-ask-spread, and the term to maturity and they are interacted with the two crisis dummies. Standard errors shown in parentheses are Huber/White standard errors and therefore robust to heteroscedasticity. The symbols *, **, and *** indicate statistical significance at the 5%, 1%, and 0.1% level, respectively.

	(1)	(2)	(3)	(4)
Currency Country	Euro Germany	Euro Non-Germany	Euro Germany	Euro Non-Germany
Volatility	-0.0762*	0.0597	-0.0921**	0.0616
	(0.0320)	(0.126)	(0.0339)	(0.123)
LIBOR	-10.01***	-9.594***	-5.091***	-10.24***
	(0.546)	(1.649)	(0.561)	(2.063)
Stock Index Return	-0.317***	-0.875***	-0.304***	-0.879***
	(0.0206)	(0.109)	(0.0204)	(0.111)
Government Spread	18.90***	10.91	16.38***	11.29
	(2.273)	(7.223)	(2.450)	(6.551)
Unemployment Rate	-10.34***	1.328		
	(1.077)	(2.410)		
Debt-GDP-Ratio Difference	-2.349***	3.579***	-0.972***	3.854***
	(0.247)	(1.004)	(0.129)	(0.938)
House Price Index Change	-7.314***	-0.666	-1.590*	-0.799
	(0.905)	(0.350)	(0.807)	(0.408)
Non-Central Government Debt	-5.551***	0.0519		
	(0.612)	(1.070)		
Financial Crisis	24.23***	7.422	25.99***	6.477
	(6.483)	(17.86)	(6.658)	(17.57)
Sovereign Debt Crisis	3.291	0.885	1.319	3.375
	(4.702)	(14.24)	(4.937)	(12.92)
CBPP1	-3.634**	-29.65***	-8.342***	-31.14***
	(1.372)	(5.809)	(1.242)	(6.163)
CBPP2	-6.262***	-8.000	-4.329**	-8.600
	(1.436)	(4.260)	(1.488)	(4.398)
CBPP2#PIIGS		37.96***		41.38***
		(9.258)		(11.39)
CBPP2#Dexia		47.10***		46.77***
		(7.033)		(7.297)
Constant	305.6***	-14.50	13.12*	-3.686
	(26.34)	(27.79)	(5.505)	(18.36)
Bond-Specific Controls	Yes	Yes	Yes	Yes
Observations	36,509	20,258	36,509	20,258
R^2 within	0.5140	0.6916	0.5036	0.6912
R^2 between	0.3299	0.7025	0.3967	0.6862
R^2 overall	0.3506	0.6676	0.4753	0.6592

time period. The interaction of CBPP2 with the PIIGS dummy is positive and highly significant, indicating that investors demanded higher risk premiums from public covered bonds issued in crisis countries during this time period. A possible explanation might be that the sovereign debt crisis was more intense during this time period than on average during the period covered by the sovereign debt crisis dummy. The reason that the effect is significant in this setting but is insignificant in column (2) of Table 3.8 is explainable by the effects of the macroeconomic variables being different between Germany and other countries, showing significant differences between different public covered-bond markets. In column (2) of Table 3.8, the effects were estimated for all countries together and German public covered bonds represented 64% of the the combined subsample, leading to possibly imprecise estimates for countries other than Germany and as a result, to the insignificance of the interaction term.

More specifically, in Table 3.9, all significant coefficients of macroeconomic factors have the expected sign for countries other than Germany. By contrast, for Germany, some unexpected effects can be observed. First, the coefficient of the debt-GDP-ratio difference is negative and significant and second, the coefficient of the unemployment rate is negative, highly significant and very distinct. These effects seem surprising, as we would generally expect increasing effects of these variables. However, despite the two economic crises, the unemployment rate in Germany fell almost constantly during the covered time period. Therefore, it might be argued that the variable is not a good representative of the macroeconomic situation in Germany. Furthermore, the term to maturity, which is included in the bond-specific controls, decreases over time for each single covered bond. After performing the within-transformation for the fixed effects estimation, these two variables have a correlation of more than 91% in the German subsample, leading to multicollinearity and, thus, biased results. For comparison, for the entire dataset, the correlation is approximately -11%. Similarly, the two highly significant and surprisingly strong effects of the house price index change and the non-central government debt can be explained. After performing the within-transformation, their correlation is -74% for the German subsample, compared to 14% in the entire dataset. Therefore, we repeat the analyses without the unemployment rate and non-central government debt. The results are shown in columns (3) and (4) of Table 3.9. Since both omitted variables are insignificant in column (2), results remain relatively stable for countries other than Germany. For Germany, however, the unpresented coefficient of the term to maturity is markedly smaller, with a value of 2.3 in column (3) compared to 10.6 in column (1), but is still highly significant. Furthermore, the effect of the house price index change is still negative and significant but less intense. The reasonableness of leaving out the two variables for the German subsample can also be seen when looking at the coefficients of determination. Whereas the R^2 within decreases by definition when leaving out a variable in a fixed effects estimation, both the between and the overall R^2 increase significantly. In contrast, for the other subsample, all three coefficients decrease slightly. The coefficient of the debt-GDP-ratio difference remains negative and significant for Germany, however, although the effect is less intense compared to column (1). A possible explanation for this could be that despite a general increase of this ratio, German BUNDs and, thus, at least partly, German public Pfandbriefe, have been considered safe-haven investments in recent years, leading to very low risk premiums, as already discussed prior to research question 4. This effect can also be seen in the analyses of Prokopczuk et al. (2013), who analyze the cover pool composition of German Pfandbriefe in more detail and thereby show that a higher share of German cover pool assets in the cover pool led to lower risk premiums even in the crisis years 2008 to 2011. Thus, investors did not assign a higher default risk to German public sector entities, despite the risen debt-GDP-ratio. This is a peculiarity for Germany, however, because in other countries, the increased indebtedness of the government has been seen as more critical, leading to higher risk premiums of public covered bonds in these countries, as shown by the significant and positive effect of the debt-GDP-ratio difference in column (4). Related to this peculiarity for Germany, the negative effect of volatility for the German subsample is noticeable, although the magnitude of the effect is rather small. This effect can be seen as an indicator of a *flight-to-safety* effect. Flights to safety take place when in times of high market stress (i.e., high stock market volatility), stock market returns are low and (government) bond returns are high.[98] This is fulfilled for the German subsample. The negative effect of volatility

[98]See e.g., Baele et al. (2013).

indicates decreasing risk premiums and, thus, increasing covered-bond prices, i.e., high returns of German public covered bonds when stock market volatility increases.

As mentioned in footnote 59, it might be argued that the interbank market is not entirely risk-free and, thus, that the asset swap spread does not describe the true risk premium of a covered bond. Therefore, as a robustness check, we repeat our main analysis of the influences of macroeconomic and event variables with the difference of the yield to maturity of a covered bond and the yield to maturity of a duration-equivalent government bond in the same currency area as dependent variable because a government bond is usually the security with the lowest possible risk in a currency area.[99] In general, the results confirm our previous findings. Therefore, we do not explicitly discuss the results of the robustness check but only present them in Tables 3.10 and 3.11.

[99]In the euro area, German BUNDs serve as the benchmark government bonds; thus, this statement should also hold there.

Table 3.10: **Robustness Check – Benchmark Spreads.**
This table reports fixed-effects estimates of macroeconomic variables and exogenous event dummies on risk premiums (in bp). Bond-specific controls are the rating, the bid-ask-spread, and the term to maturity and they are interacted with the two crisis dummies. Standard errors shown in parentheses are Huber/White standard errors and therefore robust to heteroscedasticity. The symbols *, **, and *** indicate statistical significance at the 5%, 1%, and 0.1% level, respectively.

	(1)	(2)	(3)	(4)
Currency	All	Euro	Non-Euro	Non-Euro
Country	All	All	All	All
Volatility	1.087***	0.995***	0.849***	0.730**
	(0.103)	(0.121)	(0.226)	(0.214)
6M Treasury Yield	-2.872	-0.805	-8.574	-9.588*
	(2.219)	(1.331)	(4.771)	(4.167)
Stock Index Return	-0.854***	-0.821***	-0.842***	-0.938***
	(0.0626)	(0.0489)	(0.153)	(0.142)
Government Spread	11.27	13.16	-4.281	-5.005
	(7.411)	(8.779)	(3.214)	(2.993)
Unemployment Rate	4.652*	3.091	6.719*	6.533*
	(2.334)	(2.176)	(2.597)	(2.587)
Debt-GDP-Ratio Difference	2.304***	2.004**	1.907**	1.594**
	(0.649)	(0.756)	(0.680)	(0.589)
House Price Index Change	-1.458***	-1.426***	-1.175*	-0.745
	(0.352)	(0.371)	(0.567)	(0.545)
Non-Central Government Debt	0.0451	2.534**	-1.508	-1.838*
	(0.822)	(0.875)	(0.826)	(0.767)
Financial Crisis	12.47	10.29	113.8***	111.6***
	(11.58)	(9.215)	(21.44)	(20.50)
Sovereign Debt Crisis	24.13*	21.76**	47.68**	44.81**
	(11.82)	(8.050)	(16.92)	(15.39)
CBPP1	5.593	-20.39***	-15.13*	-12.09*
	(7.436)	(2.829)	(5.742)	(5.473)
CBPP1_restricted	-29.09***			
	(8.201)			
CBPP2	30.68**	-17.84	65.64***	32.40***
	(10.18)	(13.12)	(11.02)	(8.603)
CBPP2_restricted	2.715	35.48**		
	(10.60)	(12.99)		
CBPP2#PIIGS	10.05	15.47	-16.50	19.74
	(9.912)	(11.17)	(19.72)	(17.94)
CBPP2#Dexia				122.6***
				(12.10)
Constant	24.55	-50.11	10.30	25.26
	(30.03)	(30.20)	(39.21)	(38.22)
Bond-Specific Controls	Yes	Yes	Yes	Yes
Observations	65,129	54,887	10,242	10,242
R^2 within	0.6698	0.7286	0.6759	0.7192
R^2 between	0.7506	0.4634	0.5801	0.5697
R^2 overall	0.265	0.5456	0.6258	0.6357

Table 3.11: **Robustness Check – Benchmark Spreads.**
This table reports fixed-effects estimates of macroeconomic variables and exogenous event dummies on risk premiums (in bp). Bond-specific controls are the rating, the bid-ask-spread, and the term to maturity and they are interacted with the two crisis dummies. Standard errors shown in parentheses are Huber/White standard errors and therefore robust to heteroscedasticity. The symbols *, **, and *** indicate statistical significance at the 5%, 1%, and 0.1% level, respectively.

	(1)	(2)	(3)	(4)
Currency	Euro	Euro	Euro	Euro
Country	Germany	Non-Germany	Germany	Non-Germany
Volatility	-0.0199	0.937***	-0.0187	0.916***
	(0.0353)	(0.163)	(0.0382)	(0.184)
6M Treasury Yield	-11.90***	-12.20***	-2.545***	-12.25***
	(0.805)	(2.298)	(0.763)	(2.194)
Stock Index Return	-0.288***	-1.168***	-0.288***	-1.188***
	(0.0231)	(0.107)	(0.0239)	(0.119)
Government Spread	-61.47***	13.98	-73.23***	13.94
	(2.535)	(8.841)	(2.804)	(7.961)
Unemployment Rate	-18.15***	1.387		
	(1.149)	(3.076)		
Debt-GDP-Ratio Difference	-2.689***	4.162***	-1.315***	4.349***
	(0.299)	(1.211)	(0.165)	(1.061)
House Price Index Change	-13.43***	-0.709	-8.142***	-0.758
	(1.089)	(0.426)	(0.944)	(0.513)
Non-Central Government Debt	-6.459***	1.968		
	(0.801)	(1.076)		
Financial Crisis	38.11***	-5.489	48.21***	-3.278
	(6.976)	(21.81)	(7.317)	(21.08)
Sovereign Debt Crisis	30.26***	17.68	35.38***	26.16
	(5.499)	(14.64)	(5.941)	(15.82)
CBPP1	-1.332	-38.08***	-7.372***	-38.24***
	(1.428)	(6.429)	(1.186)	(6.464)
CBPP2	-3.091	-4.191	0.859	-4.674
	(1.760)	(4.773)	(1.720)	(4.605)
CBPP2#PIIGS		47.94***		50.64***
		(9.817)		(12.92)
CBPP2#Dexia		52.10***		51.50***
		(9.622)		(9.490)
Constant	406.8***	5.252	26.06***	32.58
	(35.03)	(38.27)	(7.356)	(22.40)
Bond-Specific Controls	Yes	Yes	Yes	Yes
Observations	35,252	19,635	35,252	19,635
R^2 within	0.7673	0.7593	0.7587	0.7580
R^2 between	0.5562	0.6903	0.7964	0.6651
R^2 overall	0.5690	0.7230	0.7632	0.7095

3.5 Interim Results

Public covered bonds are one of the most important refinancing instruments for banks providing loans to public sector entities. Due to creditors of LRGs often expecting LRGs to be bailed out by the central government in times of financial distress, public covered bonds have often been considered substitutes for government bonds and therefore almost default-risk-free in the past. However, this notion has partially changed because of a significant deterioration of investors' assessment of the quality of government debt in several countries in the context of the recent sovereign debt crisis. Against this background, in this chapter, we examined what factors influence risk premiums of public covered bonds issued in several different countries and currencies. More precisely, we investigated the influences of covered bond-specific and macroeconomic variables and the effects of exogenous events such as economic crises or monetary policy measures by the ECB. In a preliminary analysis, it is shown that country-specific variables together with bond fixed effects explain more than 87% of the variance in public covered bond risk premiums. Against this background, our in-depth analyses show that besides bond-specific factors, macroeconomic variables, the financial crisis, the sovereign debt crisis, and the first purchase program by the ECB significantly influenced risk premiums.

The analysis of the effect of covered bond-specific variables shows similar influencing factors as found by Prokopczuk and Vonhoff (2012) for mortgage covered bonds, with the effects differing between non-crisis and crisis periods. Concerning the effects of macroeconomic factors, however, previous results in the literature are scarce. We find that high interest rate levels and a positive development of the stock market lead to lower risk premiums, whereas we find no evidence of a positive effect of stock market volatility. In contrast, we even find a negative effect of volatility for the German market indicating German Pfandbriefe to be attractive to investors as safe investments in times of market stress. We further show that the unemployment rate and the debt-GDP-ratio can have an increasing effect. Moreover, the development of real estate prices, which was used as a proxy for the values of mortgage covered bonds' cover pools in Prokopczuk and Vonhoff (2012), also influences risk premiums of public covered bonds due to its function as a factor describing the macroeconomic environment and as an indicator of the quality of the issuers' balance sheets.

Concerning exogenous events, the financial crisis and the sovereign debt crisis both had an increasing effect on risk premiums, although these effects are at least partly already incorporated in the effects of macroeconomic factors. For monetary policy measures by the ECB, however, the effects are mixed. Only the first purchase program for covered bonds led to lower risk premiums, whereas the second program did not have the desired effect.

We also show that there exist significant differences in the effects for public covered bonds issued in different countries or denominated in different currencies. Concerning the currency, significant differences are obtained between public covered bonds denominated in euros or in other currencies, respectively. Concerning the country, particularly for the German Pfandbrief market, the effects differ significantly from those obtained for public covered bonds issued in other countries, and at least parts of these differences can be explained by German BUNDs having been seen as safe-haven investments in recent crisis periods.

Overall, we give the first detailed overview of factors influencing risk premiums in the international public covered-bond market. In addition to factors known to influence mortgage covered bonds, we show the effects of several further macroeconomic variables, of the two recent economic crises, and of the first two covered bond purchase programs by the ECB. Furthermore, we show significant international differences between public covered-bond markets. Our results are particularly relevant for issuing banks. Particularly during crisis periods, they have an incentive to address their cover pool quality even more than is prescribed by the law, and they have an incentive to enhance the transparency of their cover pools to signal investors and thereby possibly lower their refinancing costs. Because it was shown that country-specific variables explain a large share of variation in covered bond risk premiums, particularly for issuers in countries with a distressed macroeconomy, such signals can be important to improve investors' risk assessments of their issues. Correspondingly, our results are important for public sector debtors whose loans are combined in the cover pools since the banks' refinancing costs directly affect their funding costs. Furthermore, our results are relevant for covered-bond investors. First, they can consider the obtained results in their investment decisions. By considering the typical factors influencing secondary market public covered bond risk premiums elaborated in this chapter, investors might be able to detect possibly anomalously priced public covered bonds and to exploit such anomalies. Second, they can use the results in their risk management processes concerning the public covered bonds they are invested in. This is, in particular, important for the ECB, which holds a significant amount of covered bonds as a consequence of the recent covered bond purchase programs.

3.6 Appendix

3.6.1 Panel Data Regression Methods

In the present analysis, we investigate a panel dataset, i.e., we have observations for several covered bonds, and for each of these covered bonds, we also have several observations over time. Thus, as shown in equation 3.8, in our empirical model, potential influencing factors can vary between covered bonds and over time, only between covered bonds, or only over time. For reasons of clarity, we can rewrite equation 3.8 as

$$spread_{i,t} = \beta_0 + \beta' \cdot X_{i,t} + \alpha_i + u_{i,t}, \quad i = 1, \ldots, N, t = 1, \ldots, T, \tag{3.9}$$

with N being the number of covered bonds and T the number of points in time. If for each covered bond $i = 1, \ldots, N$, there are observations for each point in time $t = 1, \ldots, T$, the panel data set is called *balanced*. However, in the present analysis, we do not have observations for every point in time for every covered bond. Thus, our data set is called *unbalanced*. The procedures explained in this section will be explained for balanced panels but they can be transferred to unbalanced data sets.[100] Potential influencing factors varying only over time are now included in the matrix $X_{i,t}$. In general, the same holds true for potential influencing factors varying only between covered bonds. However, there might be time-constant bond-individual potential influencing factors which cannot be directly observed. These are included as α_i in equation 3.9. Since these factors cannot be directly observed and they are fixed over time, the above model is often called *unobserved effects model* or *fixed effects model*.[101] In the following two subsections, we describe two different ways of estimating the effects of the potential influencing factors in such a model.

[100] See Wooldridge (2015, pp. 440ff.).
[101] See Wooldridge (2015, pp. 412f.).

3.6.1.1 Fixed Effects Estimation

Instead of using the matrix notation, we rewrite equation 3.9 as[102]

$$y_{i,t} = \beta_0 + \beta_1 \cdot x_{i,t,1} + \ldots + \beta_m \cdot x_{i,t,m} + \alpha_i + u_{i,t}, \quad i = 1, \ldots, N, t = 1, \ldots, T, \tag{3.10}$$

with m being the number of independent variables. In panel data sets, the unobserved effect α_i is often assumed to be correlated with the other explanatory variables. However, since it cannot be observed, it cannot be included in an empirical analysis. Thus, when using pooled OLS to estimate model 3.10, α_i would be included in the error term. This new error term could be written as $v_{i,t} = \alpha_i + u_{i,t}$ and in the model

$$y_{i,t} = \beta_0 + \beta_1 \cdot x_{i,t,1} + \ldots + \beta_m \cdot x_{i,t,m} + v_{i,t}, \quad i = 1, \ldots, N, t = 1, \ldots, T, \tag{3.11}$$

the error term and the independent variables would be correlated,[103] and thus, the Gauss-Markov assumptions[104] would be violated. Hence, using pooled OLS would lead to biased results. To overcome this problem, we try to construct a model in which α_i does not appear. Therefore, in a first step, we compute the average of equation 3.10 for every covered bond i:[105]

$$\overline{y}_i = \beta_0 + \beta_1 \cdot \overline{x}_{i,1} + \ldots + \beta_m \cdot \overline{x}_{i,m} + \alpha_i + \overline{u}_i, \quad i = 1, \ldots, N, \tag{3.12}$$

with

$$\overline{y}_i = \frac{1}{T} \sum_{t=1}^{T} y_{i,t}, \tag{3.13}$$

$$\overline{x}_{i,l} = \frac{1}{T} \sum_{t=1}^{T} x_{i,t,l}, \quad l = 1, \ldots, m, \text{ and} \tag{3.14}$$

$$\overline{u}_i = \frac{1}{T} \sum_{t=1}^{T} u_{i,t}. \tag{3.15}$$

[102] We replace $spread_{i,t}$ by $y_{i,t}$ for a better readability.
[103] See Wooldridge (2015, p. 413).
[104] See Wooldridge (2015, p. 76).
[105] See Wooldridge (2015, p. 435).

Note that both the constant β_0 and the unobserved effects α_i remain unchanged when averaging equation 3.10. Next, equation 3.12 can be subtracted from equation 3.10, leading to:

$$\ddot{y}_{i,t} = \beta_1 \cdot \ddot{x}_{i,t,1} + \ldots + \beta_m \cdot \ddot{x}_{i,t,m} + \ddot{u}_{i,t}, \quad i = 1, \ldots, N, t = 1, \ldots, T, \tag{3.16}$$

with

$$\ddot{y}_{i,t} = y_{i,t} - \overline{y}_i, \quad \ddot{x}_{i,t,l} = x_{i,t,l} - \overline{x}_{i,l}, l = 1, \ldots, m, \text{ and } \ddot{u}_{i,t} = u_{i,t} - u_i. \tag{3.17}$$

By subtracting the averages from the original data, both β_0 and, more important, α_i are removed from the model. This time-demeaning is called the *within transformation*. Equation 3.16 can now be estimated using pooled OLS, leading to unbiased results. The concept of performing the within transformation and subsequently applying pooled OLS is called *fixed effects estimation*. Instead of using the fixed effects estimation, equation 3.10 can be directly estimated using pooled OLS if we explicitly include a dummy variable for every covered bond in the dataset. However, this would result in a large number of explanatory variables and would, thus, be highly computationally expensive. Furthermore, the resulting estimates of the $\beta_l, l = 1, \ldots, m$, would be exactly the same as those obtained from the fixed effects estimation.[106] The biggest disadvantage of the fixed effects estimation is that effects of time-constant variables cannot be estimated because after the time-demeaning the corresponding values are zero in every point in time.[107] To overcome this problem, we present the so-called *random effects estimation* in the next subsection.

[106]See Wooldridge (2015, p. 438f.) for more details.
[107]See Wooldridge (2015, p. 435f.).

3.6.1.2 Random Effects Estimation

As mentioned in the last subsection, the unobserved effect α_i is often assumed to be correlated with the other explanatory variables. However, if we assume no such correlation, i.e., if we assume

$$Cov(x_{i,t,l}, \alpha_i) = 0, \quad i = 1, \ldots, N, t = 1, \ldots, T, \quad l = 1, \ldots, m, \tag{3.18}$$

using fixed effects estimation would result in inefficient estimators due to the exclusion of α_i. On the other hand, applying pooled OLS on model 3.11 would lead to consistent estimators.[108] However, because α_i is included in the error term in this model, the error terms $v_{i,t}$ exhibit serial correlation, leading to incorrect standard errors.[109] This problem can be solved by using Generalized Least Squares (GLS). Therefore, we construct the following model:

$$\begin{aligned} y_{i,t} - \theta \cdot \overline{y}_i =& \beta_0 \cdot (1-\theta) + \beta_1 \cdot (x_{i,t,1} - \theta \cdot \overline{x}_{i,1}) + \ldots \\ & + \beta_m \cdot (x_{i,t,m} - \theta \cdot \overline{x}_{i,m}) + (v_{i,t} - \theta \cdot \overline{v}_i), i = 1, \ldots, N, t = 1, \ldots, T, \end{aligned} \tag{3.19}$$

with θ being defined as

$$\theta = 1 - [\sigma_u^2/(\sigma_u^2 + T \cdot \sigma_\alpha^2)]^{1/2}, \text{ with } \sigma_u^2 = Var(u_{i,t}) \text{ and } \sigma_\alpha^2 = Var(\alpha_i). \tag{3.20}$$

By construction, θ lies between zero and one. Thus, instead of subtracting the entire averages, as in equation 3.16, only a fraction of the averages is subtracted from the original data, i.e., we have quasi-demeaned data. Model 3.19 can then be estimated using pooled OLS. However, because in practice, θ is unknown, it has to be estimated before, using estimates of σ_a^2 and σ_u^2 based on pooled OLS or fixed effects estimations. The concept of performing the quasi-demeaning using such estimates of θ and subsequently applying pooled OLS is called *random effects estimation*. The biggest advantage of this

[108]See Wooldridge (2015, p. 441).
[109]See Wooldridge (2010, p. 291).

method compared to fixed effects is that effects of time-constant explanatory effects can be estimated.[110]

3.6.2 Decision between Different Models

3.6.2.1 Breusch/Pagan Test

If (some of) the explanatory variables of interest are time-constant, fixed effects estimation cannot be applied, as mentioned in Section 3.6.1.1. Thus, either random effects estimation or pooled OLS can be applied in this case. As mentioned in Section 3.6.1.2, pooled OLS leads to consistent estimators but incorrect standard errors if an unobserved effect α_i exists. Therefore, random effects estimation is advantageous compared to pooled OLS in this case. If no such effect exists, however, pooled OLS is efficient.[111] Thus, to choose between these models, we need to test whether an unobserved effect exists. When estimating equation 3.11 using pooled OLS, the variance of the error term is defined as follows:[112]

$$E(v_{i,t}^2) = E(\alpha_i^2) + 2 \cdot E(\alpha_i u_{i,t}) + E(u_{i,t}^2) = \sigma_\alpha^2 + \sigma_u^2 \text{ with } E(\alpha_i u_{i,t}) = 0. \tag{3.21}$$

Thus, testing the non-existence of an unobserved effect is equivalent to testing the hypothesis $H_0: \ \sigma_\alpha^2 = 0$. This hypothesis can be tested by the Breusch/Pagan Lagrange-multiplier test.[113] If the null hypothesis cannot be rejected, pooled OLS estimation is appropriate, and if the null hypothesis is rejected, random effects estimation is appropriate. The test was first introduced by Breusch and Pagan (1980) and later refined by Baltagi and Li (1990).[114]

[110] See Wooldridge (2015, p. 442).
[111] See Wooldridge (2010, p. 299).
[112] See Wooldridge (2010, p. 293).
[113] See Wooldridge (2010, p. 299).
[114] See also StataCorpLP (2013b, pp. 393f.) for further information on the implementation of the test in Stata.

3.6.2.2 Hausman Test

If, in contrast to the previous subsection, the main explanatory variables of interest are time-varying, fixed effects estimation and random effects estimation are possible. However, as mentioned in Sections 3.6.1.1 and 3.6.1.2, the two methods comprise different assumptions regarding the correlation between the unobserved effect and the other explanatory variables. If there exists a non-zero correlation, fixed effects estimation is appropriate. If, in contrast, the correlation is zero, random effects estimation is appropriate. Thus, to make a decision between the two models, we have to test which one of the two assumptions holds. This can be done using the Hausman test developed by Hausman (1978). This test is based on the differences between the estimates obtained by fixed effects estimation and random effect estimation, respectively, and, as mentioned in Section 3.4.3, the test has consistency of both estimators and efficiency of the random effects estimator under the null hypothesis, and consistency only of the fixed effects estimator as the alternative. The test statistic has the following form:[115]

$$H = (\widehat{\beta}_{FE} - \widehat{\beta}_{RE})^T [V(\widehat{\beta}_{FE}) - V(\widehat{\beta}_{RE})]^{-1} (\widehat{\beta}_{FE} - \widehat{\beta}_{RE}). \tag{3.22}$$

$\widehat{\beta}_{FE}$ and $\widehat{\beta}_{RE}$ are the m-dimensional vectors of fixed effects and random effects estimates of β in equation 3.9, and $V(\widehat{\beta}_{FE})$ and $V(\widehat{\beta}_{RE})$ the corresponding variance-covariance-matrices. H is χ^2-distributed with m degrees of freedom and to decide whether the null hypothesis should be rejected, H can be compared to critical values of this distribution.[116] If the null hypothesis cannot be rejected, random effect estimation should be applied, and if the null hypothesis is rejected, the test indicates that fixed effects estimation should be applied. However, the test only investigates statistically significant differences in the estimates and as Wooldridge (2015) states, it has to be distinguished between pure statistical significance and practical (or economical) significance.[117]

[115] See Wooldridge (2010, p. 328).
[116] See Wooldridge (2010, pp. 328ff.) and Wooldridge (2015, pp. 444f.) for further details, and see StataCorpLP (2013b, pp. 388ff.) for further information on the implementation of the test in Stata.
[117] See Wooldridge (2015, p. 444).

3.6.3 Different Types of Panel Data Coefficients of Determination

In the result tables of our empirical analyses, we include three different coefficients of determinations, namely R^2 within, R^2 between, and R^2 overall. These are calculated as follows. Let $\hat{\beta}_0$ and $\hat{\beta}$ be the regression estimates obtained for β_0 and β. Using these estimates, we compute the following predictions:

$$\hat{\ddot{y}}_{i,t} = \hat{\beta}_0 + \hat{\beta}' \cdot \ddot{X}_{i,t}, \tag{3.23}$$

$$\hat{\overline{y}}_i = \hat{\beta}_0 + \hat{\beta}' \cdot \overline{X}_i, \tag{3.24}$$

$$\hat{y}_{i,t} = \hat{\beta}_0 + \hat{\beta}' \cdot X_{i,t}. \tag{3.25}$$

Subsequently, the squared correlations between the predicted values from equations 3.23 to 3.25 and the true values $\ddot{y}_{i,t}$, $\overline{y}_i$, and $y_{i,t}$ are computed. The squared correlation between $\hat{\ddot{y}}_{i,t}$ and $\ddot{y}_{i,t}$ is called R^2 within because it relies on the observations after performing the within-transformation. The squared correlation between $\hat{\overline{y}}_i$ and $\overline{y}_{i,t}$ is called R^2 between because changes over time are ignored and only differences between different covered bonds are considered. Finally, the squared correlation between $\hat{y}_{i,t}$ and $y_{i,t}$ is called R^2 overall because it ignores to which covered bond or to which point in time an observation belongs.[118]

[118]See StataCorpLP (2013b, p. 368).

4 Risk Assessment of Mortgage Covered Bonds: International Evidence[119]

4.1 Motivation

In the last chapter, we investigated factors influencing risk premiums of public covered bonds because this has been an understudied field of research so far. However, as we have seen in Section 2.1.1, the outstanding volume of mortgage covered bonds is considerably higher than the outstanding volume of public covered bonds in the international market. Furthermore, mortgage covered bonds are issued in far more countries than public covered bonds,[120] but factors influencing risk premiums of mortgage covered bonds have thus far only been investigated rarely. Against this background, we want to investigate factors influencing risk premiums in the international mortgage covered-bond market in the present chapter.

As shown in the literature overview in Section 3.1, for the German Pfandbrief market, prior studies consider yield spreads compared to German sovereign bonds to be driven mainly by liquidity differences,[121] although Prokopczuk et al. (2013) show that Pfand-

[119] This chapter is mainly based on the article „Risk Assessment of Mortgage Covered Bonds: International Evidence“ which is a joint work with Marc Gürtler and was published in *Finance Research Letters* (Gürtler and Neelmeier, 2018c).

[120] See, e.g., ECBC (2016, Ch. 5).

[121] See Koziol and Sauerbier (2007); Kempf et al. (2012).

brief risk premiums also exhibit a credit-risk component, what can also be shown for the international covered-bond market.[122] The most comprehensive study of factors influencing risk premiums of mortgage covered bonds is conducted by Prokopczuk and Vonhoff (2012). They focus on euro-denominated mortgage covered bonds issued in France, Germany, Spain, and the UK, and they show that, besides covered bond-specific variables, also other variables describing the general development of capital markets, e.g., the stock market development and the general interest rate level, affect risk premiums. Furthermore, they show that the development of real estate indices in a country influences risk premiums of mortgage covered bonds and substantiate this with these indices serving as proxies for the quality of the cover pools, as discussed in the previous chapter.[123] We could verify these findings for risk premiums of public covered bonds issued in ten different countries and several different currencies, in the previous chapter. Moreover, we showed effects of additional macroeconomic variables, the financial crisis, the sovereign debt crisis, and the first two covered bond purchase programs by the European Central Bank (*ECB*).

Against this background, we want to examine influencing factors of risk premiums in the entire international mortgage-covered-bond market in the present chapter. By doing this, we provide the following contributions. First, we show that results obtained by Prokopczuk and Vonhoff (2012) for euro-denominated mortgage covered bonds issued in France, Germany, Spain, and the UK also hold for a much broader dataset with mortgage covered bonds issued in 22 different countries and ten different currencies. Second, we show that additional factors influencing risk premiums of public covered bonds shown in the previous chapter also affect risk premiums of mortgage covered bonds. Because we will show that factors influencing risk premiums are similar for public and mortgage covered bonds, we also investigate risk premiums of both mortgage and public covered bonds together. Although the influencing factors are generally similar, we show that differences regarding the influence of macroeconomic variables also serving as proxies for

[122] See e.g., Packer et al. (2007).

[123] Pinto and Correia (2017) also investigate bond-individual risk premiums of mortgage covered bonds. However, they do not include macroeconomic variables not directly related to the capital market in their analysis and their main focus is on the comparison of covered bonds with ABS/MBS.

the quality of the cover pools exist between the two covered-bond types. Since the general procedure of the analysis in this chapter is similar to that in Chapter 3, we will keep the explanations a little briefer than in the previous chapter.

The remainder of the chapter is structured as follows. In the next section, we describe the employed dataset. In the third section, we present the results of the empirical analyses, and in the fourth section, we provide a short conclusion.

4.2 Data

4.2.1 Sample Selection and Variables

We obtain data for both mortgage and public covered bonds. Because we aim to transfer results obtained for public covered bonds in the previous chapter to the mortgage-covered-bond market, among other things, we use the same way to select the sample. For the period from January 2006 to December 2012, we obtain weekly asset swap spreads for all fixed-coupon bonds that are labeled as 'Pfandbriefe', 'Jumbo Pfandbriefe' or 'covered', that are issued before the end of 2012 and that have a minimum issue size of €250 million or equivalent if the issuing currency is not euro from Bloomberg.[124] The asset swap spread will be the dependent variable in our empirical analyses. Analogous to the previous chapter, we change the type of collateral to 'mortgages' if bonds are labeled as being backed by public loans but are issued in countries, in which no public covered bonds exist according to the annually published 'European Covered Bond Fact Book' by the ECBC. We again exclude observations, for which the term to maturity is less than one year and we again manually investigate observations for which there is a (positive or negative) jump in the asset swap spread from one date to the next one of more than three times the standard deviation of asset swap spreads in the entire dataset. If for such

[124]As in the previous chapter, we use weekly data, which allows us to obtain good comparability with the existing literature. Furthermore, weekly data provides a good compromise between high data frequency and congruence of the dependent variable's data frequency with the independent variables' data frequency (several independent variables only change quarterly).

observations there is no corresponding movement of the bond's price, we delete them from the dataset, otherwise we keep them. Because the standard deviation of asset swap spreads differs between mortgage and public covered bonds, we conduct this procedure for the two covered-bond types separately. Overall, we delete 38 observations. Finally, we winsorize risk premiums at the 0.5% and 99.5% levels separately for the two covered-bond types and for each country in the dataset. Altogether, our dataset contains 250,304 observations from 1,827 covered bonds issued in 22 different countries and ten different currencies. The subsample of mortgage covered bonds contains 177,737 observations from 1,267 bonds. Since we used the same way to select our sample and the same data cleaning procedures as in the previous chapter, the subsample of public covered bonds is identical to the dataset employed in Chapter 3, and contains 72,567 observations from 560 bonds.

Regarding the explanatory variables, we likewise follow the procedure of the last chapter, in which we also employed variables shown to influence risk premiums of mortgage covered bonds by Prokopczuk and Vonhoff (2012). We obtain the variables from Bloomberg, the credit rating agencies, the ECB, Thomson Reuters Advanced Analytics/Thomson Reuters Eikon, Stats NZ Tatauranga Aotearoa, the Federal Reserve Bank of Dallas, and the National Bank of Austria. An overview of all possible explanatory variables and the expected directions of the influences are shown in Table 4.1.

Ratings are again defined as average ratings of Fitch, Moody's, and S&P. We group all ratings lower than or equal to BBB, because only 0.04% and 0.03% of observations have a BB- or B-rating, respectively. The variable *LIBOR* is the only one with regard to the currency,[125] and the variable *volatility* only changes over time and is the same for all covered bonds. All other macroeconomic variables are with regard to the country a covered bond is issued in. Of these variables, *stock index return* and *government spread* are obtained on a weekly basis,[126] whereas *unemployment rate*, *debt-GDP-ratio difference* and *house price index change* change only quarterly. For New Zealand, the debt-GDP-ratio difference is obtainable only yearly. However, observations from New Zealand only

[125] Again, for the Norwegian krone, we use the NIBOR (Norwegian Interbank Offered Rate).

[126] For Luxembourg, we againn subtract the ten-year swap rate of the yield to maturity of a government bond with a maturity of ten years to calculate the government spread.

account for 0.17% of the entire dataset and 0.24% of the subsample of mortgage covered bonds, respectively. Thus, the effects should be negligible.

Besides macroeconomic variables, we also include the same dummy variables for the financial crisis, the sovereign debt crisis, and the first two covered bond purchase programs by the ECB as in the previous chapter. We again use the threshold regression method by Hansen (1999) to estimate the start and end dates of the two crises. In our dataset of both covered-bond types, this leads to exactly the same time periods as in the dataset of only public covered bonds in Chapter 3. The financial crisis ranges from 10 October 2008 to 08 October 2009. The sovereign debt crisis starts at the subsequent day and lasts until the end of our dataset. For the two purchase programs, we again include pure time dummies for the periods starting at the announcements dates of the two purchase programs until the end of the purchases (07 May 2009 until 30 June 2010 for *CBPP1* and 06 October 2011 until 31 October 2012 for *CBPP2*), and we further include dummies restricted to the time periods of the purchase programs and to covered bonds fulfilling the requirements (*CBPP1_restricted* and *CBPP2_restricted*).

Table 4.1: **Variable Overview.**
This table gives an overview about the different variables used in our analyses and the expected direction of the effects of the variables.

Variable	Description	Expected Influence
Dependent Variables		
Asset Swap Spread	Asset swap spread in basis points	
Covered Bond Specific		
Mortgage	Dummy for mortgage covered bonds	
AA	Dummy for AA-rating	+
A	Dummy for A-rating	+
≤BBB	Dummy for BBB-rating or lower	+
NR	Dummy for no rating	+
Bid-Ask-Spread	Difference between ask and bid price	+
Term to Maturity	Term to maturity in years	+
Macroeconomic		
LIBOR	Six-months LIBOR-rate in percentage points	-
Stock Index Return	Percentage change of the benchmark stock index in a country (e.g., DAX for Germany, Dow Jones Industrial Average for the U.S.) in previous 52 weeks	-
Volatility	Implied Volatility index of the EURO STOXX 50 (VSTOXX)	+
Government Spread	Swap spread of a five-year-government bond	+
Unemployment Rate	Unemployment rate in percentage points	+
Debt-GDP-Ratio Difference	Change of government debt-gdp-ratio in the previous four quarters	+
House Price Index Change	Percentage change of the house price index in the previous four quarters	-
Event Dummies		
Financial Crisis	Dummy for the financial crisis following the collapse of Lehman Brothers	+
Sovereign Debt Crisis	Dummy for the sovereign debt crisis	+
CBPP1	Dummy for the first covered bond purchase program	-
CBPP1_restricted	Dummy for the first covered bond purchase program and covered bond must be eligible	-
CBPP2	Dummy for the second covered bond purchase program	-
CBPP2_restricted	Dummy for the second covered bond purchase program and covered bond must be eligible	-

4.2.2 Descriptive Statistics

In Table 4.2, summary statistics for covered bond-specific dummy variables are presented. All summary statistics are presented for the entire dataset as well as separately for mortgage and public covered bonds, respectively.[127] More than 70% of covered bonds are denominated in euros, and there are approximately twice as many mortgage covered bonds than public covered bonds. Noticeably, only one covered bond with 40 observations is denominated in Danish kroner (DKK), because most covered bonds in Denmark are tap issues, i.e., new tranches of a covered bond are issued periodically.[128] For that reason, there is no fixed issue size and because we consider the issue size to be a possible influencing factor on risk premiums, we cannot include such covered bonds in our analyses. Actually, many more are DKK-denominated.[129] Mortgage covered bonds are issued in 22 different countries, whereas public covered bonds are issued only in ten countries.

Most covered bonds are issued in Germany. However, this is driven mainly by the high share of Germany in public covered bonds, as already seen in the previous chapter. Regarding mortgage covered bonds, most bonds come from Spain, followed by Switzerland and France.[130] Concerning the rating, approximately 80% of mortgage covered bonds are rated AAA, compared to more than 90% of public covered bonds. Accordingly, the share of lower-rated covered bonds is considerably higher for mortgage covered bonds compared to public covered bonds. Therefore, in contrast to our analysis in the last chapter, we do not have to group covered bonds with an A- and a BBB-rating, but we group all covered bonds with a rating of BBB or lower. Moreover, the share of non-rated covered bonds is considerably higher for mortgage covered bonds. Thus, we refrain from assigning substitutional ratings to covered bonds without a rating, as we have done in Section 3.3.2.1.

[127] The summary statistics for the public covered bond dataset are similar to those in Section 3.3.3.
[128] See Falch et al. (2013).
[129] See ECBC (2016, Ch. 5).
[130] There is one Greek covered bond in our dataset. Because Greece de facto defaulted in 2012, we cannot obtain the variable *government spread* for this covered bond after the haircut for Greece in March 2012. Therefore, we only include this bond until March 2012.

Table 4.2: **Summary Statistics: Covered Bond Specific Descriptive Variables.**
This table presents an overview of several covered bond specific descriptive variables differentiated between mortgage and public covered bonds.

	Bonds						Observations					
	Overall		Mortgage		Public		Overall		Mortgage		Public	
	#	%	#	%	#	%	#	%	#	%	#	%
Currency												
AUD	8	0.44	5	0.39	3	0.54	1,329	0.53	440	0.25	889	1.23
CAD	5	0.27	3	0.24	2	0.36	508	0.20	317	0.18	191	0.26
CHF	204	11.17	181	14.29	23	4.11	30,913	12.35	27,118	15.26	3,795	5.23
DKK	1	0.05	1	0.08	–	–	40	0.02	40	0.02	–	–
EUR	1,295	70.88	833	65.75	462	82.50	181,482	72.50	124,715	70.17	56,767	78.23
GBP	34	1.86	22	1.74	12	2.14	4,518	1.81	2,060	1.16	2,458	3.39
JPY	9	0.49	2	0.16	7	1.25	1,817	0.73	371	0.21	1,446	1.99
NOK	5	0.27	4	0.32	1	0.18	124	0.05	89	0.05	35	0.05
SEK	75	4.11	75	5.92	–	–	11,395	4.55	11,395	6.41	–	–
USD	191	10.45	141	11.13	50	8.93	18,178	7.26	11,192	6.30	6,986	9.63
Total	1,827		1,267		560		250,304		177,737		72,567	
Country												
Australia	26	1.42	26	2.05	–	–	813	0.32	813	0.46	–	–
Austria	36	1.97	7	0.55	29	5.18	4,720	1.89	714	0.40	4,006	5.52
Belgium	2	0.11	2	0.16	–	–	8	0.00	8	0.00	–	–
Canada	65	3.56	65	5.13	–	–	5,670	2.27	5,670	3.19	–	–
Denmark	14	0.77	14	1.10	–	–	1,380	0.55	1,380	0.78	–	–
Finland	25	1.37	25	1.97	–	–	2,589	1.03	2,589	1.46	–	–
France	261	14.29	175	13.81	86	15.36	39,561	15.81	23,979	13.49	15,582	21.47
Germany	526	28.79	162	12.79	364	65.00	58,142	23.23	19,162	10.78	38,980	53.72
Greece	1	0.05	1	0.08	–	–	127	0.05	127	0.07	–	–
Hungary	3	0.16	3	0.24	–	–	245	0.10	245	0.14	–	–

Continued on next page

	Bonds						Observations					
	Overall		Mortgage		Public		Overall		Mortgage		Public	
	#	%	#	%	#	%	#	%	#	%	#	%
Ireland	34	1.86	8	0.63	26	4.64	6,424	2.57	1,541	0.87	4,883	6.73
Italy	43	2.35	38	3.00	5	0.89	4,728	1.89	3,816	2.15	912	1.26
Luxembourg	27	1.48	–	–	27	4.82	4,227	1.69	–	–	4,227	5.82
Netherlands	40	2.19	40	3.16	–	–	5,217	2.08	5,217	2.94	–	–
Norway	59	3.23	58	4.58	1	0.18	4,667	1.86	4,632	2.61	35	0.05
New Zealand	8	0.44	8	0.63	–	–	425	0.17	425	0.24	–	–
Portugal	18	0.99	17	1.34	1	0.18	2,753	1.10	2,573	1.45	180	0.25
South Korea	6	0.33	6	0.47	–	–	731	0.29	731	0.41	–	–
Spain	220	12.04	203	16.02	17	3.04	47,387	18.93	44,382	24.97	3,005	4.14
Sweden	127	6.95	127	10.02	–	–	17,487	6.99	17,487	9.84	–	–
Switzerland	176	9.63	176	13.89	–	–	25,646	10.25	25,646	14.43	–	–
United Kingdom	103	5.64	99	7.81	4	0.71	15,707	6.28	14,950	8.41	757	1.04
United States	7	0.38	7	0.55	–	–	1,650	0.66	1,650	0.93	–	–
Total	1,827		1,267		560		250,304		177,737		72,567	
Rating												
AAA	—		—		—		207,603	82.94	141,430	79.57	66,173	91.19
AA	—		—		—		24,056	9.61	18,931	10.65	5,125	7.06
A	—		—		—		6,544	2.61	6,021	3.39	523	0.72
≤BBB	—		—		—		2,611	1.04	2,477	1.39	134	0.18
NR	—		—		—		9,490	3.79	8,878	5.00	612	0.84
Total	—		—		—		250,304		177,737		72,567	

In Table 4.3, summary statistics for several covered bond-specific variables for the mortgage covered bond sub-sample are presented. Compared to public covered bonds,[131] it can be seen that, in general, mortgage covered bonds have higher risk premiums, higher bid-ask-spreads, and higher terms to maturity than public covered bonds. In addition, the average maturity and the average issue size are higher for mortgage covered bond whereas the coupon is slightly lower on average.

Table 4.3: **Summary Statistics: Covered Bond-specific Variables.**
This table reports summary statistics for the asset swap spread, for several further time-varying covered bond-specific variables on the observation level, and for time-constant covered bond-specific variables on the bond level for mortgage covered bonds.

Variable	**Obs.**	**mean**	**sd**	**min**	**p25**	**p50**	**p75**	**max**
Asset Swap Spread (bp)	177,737	77.8	121.7	-66.1	2.0	34.6	100.5	1131.6
Bid-Ask-Spread (%)	177,737	0.41	0.49	0.00	0.13	0.25	0.50	8.16
Term to Maturity (years)	177,737	5.59	4.15	1.00	2.83	4.52	7.28	49.22
Maturity (years)	1,267	7.10	4.07	1.40	5.00	5.54	10.01	49.22
Volume (millions of euros)	1,267	1325.9	1018.9	250.0	594.3	1115.1	1600.0	8961.0
Logvolume	1,267	20.76	0.71	19.34	20.20	20.83	21.19	22.92
Coupon (%)	1,267	3.34	1.22	0.00	2.38	3.50	4.25	7.25

Analogous to the previous chapter, a lot of the heterogeneity in the asset swap spreads is observable between the different countries, as shown in Table 4.4. With -6 bp, Swiss mortgage covered bonds have the lowest asset swap spread, on average. On the other hand, mortgage covered bonds from Ireland have the highest average risk premiums with 320 bp, followed by Portugal, Italy, and Spain, i.e., the countries directly affected by the sovereign debt crisis. The average asset swap spread is even considerably higher in Greece. However, as shown in Table 4.2, there is only one covered bond with 127 observations from Greece in the dataset, leading to the corresponding value not being an appropriate representative.

[131] See Table 3.3 in Section 3.3.3.

Table 4.4: **Summary Statistics: Asset Swap Spreads in Different Countries.** This table reports summary statistics for the dependent variable asset swap spread (in bp) on a country level for mortgage covered bonds.

Country	mean	sd	min	p25	p50	p75	max
Australia	59.6	31.5	5.6	37.3	52.6	78.9	143.8
Austria	48.8	56.1	-23.0	20.8	45.0	58.4	448.5
Belgium	23.3	3.1	20.5	21.1	22.2	25.6	28.1
Canada	31.9	25.3	-11.3	14.8	28.2	42.3	152.6
Denmark	53.2	40.5	-66.1	34.2	50.4	64.7	180.7
Finland	29.6	25.4	-15.2	8.9	28.2	48.4	108.2
France	42.9	44.2	-27.2	3.5	36.8	69.9	179.7
Germany	11.6	26.2	-37.6	-4.8	4.2	21.7	146.6
Greece	610.6	301.8	78.3	450.0	578.2	862.2	1131.6
Hungary	165.1	186.8	12.5	26.2	80.5	250.2	828.1
Ireland	319.6	294.8	-3.8	43.6	221.5	578.3	1017.0
Italy	205.1	105.3	-5.0	124.6	207.5	286.7	446.3
Netherlands	53.2	38.2	-11.6	26.3	50.9	72.6	179.0
Norway	43.0	31.9	-18.0	19.4	38.4	58.9	143.9
New Zealand	70.3	32.2	14.8	43.0	68.1	84.3	155.1
Portugal	291.2	250.5	0.0	66.2	245.4	455.0	1037.6
South Korea	172.6	43.9	92.1	145.8	167.3	198.1	362.9
Spain	163.3	154.3	-10.6	25.0	131.7	262.0	669.9
Sweden	34.0	34.3	-27.2	3.5	29.5	59.9	120.5
Switzerland	-5.9	16.9	-43.6	-16.6	-9.3	1.6	90.3
United Kingdom	100.3	75.3	-10.4	45.1	94.7	138.5	423.3
United States	116.6	101.2	-1.7	49.6	95.4	135.6	437.8
Total	77.8	121.7	-66.1	2.0	34.6	100.5	1131.6

In Table 4.5, the number of issuers in the different countries is presented. German issuers form the largest group in our dataset, followed by Spain and France. As mentioned in footnote 22, there exist so-called multi-issuer Cédulas in Spain, in which several issuers combine their covered-bond issuances. For these issues, we use the company providing all services with regard to the issuance of the multi-issuer Cédulas as the 'issuer'. Overall, there are three such companies with 37 issues in the dataset. Apart from Greece, where there is only one issuer with one outstanding mortgage covered bond in our dataset, there are multiple issuers in every country. Thus, analogous to the public covered-bond market, in no country the entire mortgage covered-bond market is dominated by just one financial institution.

Table 4.5: **Summary Statistics: Number of Issuers in Different Countries and Periods.**
This table reports the number of different issuers of mortgage covered bonds in each country in the three different time periods pre-crisis, financial crisis, and sovereign debt crisis.

Country	Entire Sample	Pre-Crisis	Financial Crisis	Sovereign Debt Crisis
Australia	4	0	0	4
Austria	3	1	1	3
Belgium	2	0	0	2
Canada	7	3	3	7
Denmark	3	2	2	3
Finland	6	3	4	6
France	15	8	9	14
Germany	33	26	22	28
Greece	1	0	0	1
Hungary	2	2	2	2
Ireland	3	2	2	3
Italy	9	2	4	8
Netherlands	5	3	3	5
Norway	7	4	4	7
New Zealand	5	0	0	5
Portugal	6	5	6	6
South Korea	2	0	1	2
Spain	29	24	24	24
Sweden	7	7	7	7
Switzerland	4	2	2	4
United Kingdom	14	6	5	13
United States	2	2	2	2
Total	169	102	103	156

4.3 Empirical Results

In this section, we will examine whether we can verify similar influencing factors of risk premiums of mortgage covered bonds as of public covered bonds. Therefore, we again start with a preliminary analysis in the next subsection. Subsequently we investigate effects of bond-specific, macroeconomic, and event variables using random effects and fixed effects estimations in Sections 4.3.2 and 4.3.3.

4.3.1 Preliminary Analysis

In the preliminary analysis, we again examine how much of the variance in risk premiums can be explained by the country, the currency, bond fixed effects, issuer fixed effects, or time effects, as well as by interactions of these factors. The results are shown in Table 4.6.

Table 4.6: **Preliminary Analysis.**
This table reports coefficients of determination of pooled OLS estimations of the influence of several dummy variables on risk premiums (in bp).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Country FE	Yes	Yes								
Currency FE		Yes								
Bond FE			Yes	Yes				Yes	Yes	Yes
Quarter FE				Yes						
Country#Quarter FE					Yes			Yes		Yes
Currency#Quarter FE						Yes				Yes
Issuer#Quarter FE							Yes		Yes	
Independent Variables	21	30	1,266	1,293	476	193	2,704	1,721	3,784	1,876
R^2	0.3811	0.3865	0.5437	0.7110	0.8883	0.3109	0.9538	0.9446	0.9700	0.9468
adj. R^2	0.3810	0.3864	0.5404	0.7089	0.8880	0.3101	0.9531	0.9440	0.9694	0.9463

The structure of Table 4.6 is similar to that of Table 3.6. Bond fixed effects and time-varying country-specific factors explain a high fraction of the variance in risk premiums, as can be seen in columns (3), (6), and (8). Issuer fixed effects interacted with quarter fixed effects even increase the explained fraction of the variance (columns (7) and (9)) but due to the cost of a considerably higher number of independent variables. Thus, bond fixed effects and time-varying country-specific variables are important factors influencing risk premiums of mortgage covered bonds, confirming our results obtained for public covered bonds in the previous chapter.

4.3.2 Analysis of Covered Bond-specific Factors

In the previous subsection, we have shown that covered bond-specific variables are important factors influencing risk premiums of mortgage covered bonds. We use random effects estimations to examine what bond-specific variables significantly affect risk premiums. As in Section 3.4.2, using the Lagrange-multiplier test by Breusch and Pagan (1980) to decide between random effects and pooled OLS leads to random effects being appropriate. We control for the currency, the issuer, and time-varying country-specific effects by including corresponding dummy variables. The results are shown in Table 4.7.

Table 4.7: **Effect of Covered Bond-specific Variables on Risk Premiums.** This table reports random effects estimates of covered bond-specific variables on risk premiums (in bp). The base rating is AAA. Standard errors shown in parentheses are computed using the Huber/White/sandwich estimator of the variance-covariance-matrix and are therefore robust to heteroscedasticity and serial correlation. The symbols *, **, and *** indicate statistical significance at the 5%, 1%, and 0.1% level, respectively.

	(1)	(2)
Coupon	-1.091	1.194
	(0.775)	(0.810)
Logvolume	-3.690*	-2.429
	(1.579)	(1.280)
Maturity	2.396***	0.322
	(0.289)	(0.375)
AA		15.51***
		(2.378)
A		57.32***
		(5.206)
BBB		117.6***
		(9.626)
NR		4.162*
		(2.065)
Term to Maturity		0.747*
		(0.301)
Bid-Ask-Spread		35.96***
		(2.572)
Constant	140.4***	71.47**
	(31.01)	(25.17)
Country#Quarter FE	Yes	Yes
Currency FE	Yes	Yes
Issuer FE	Yes	Yes
Observations	177,737	177,737
R^2 within	0.8785	0.8978
R^2 between	0.9633	0.9705
R^2 overall	0.9289	0.9418

In column (1), we only include time-constant bond-specific variables. While no effect of the coupon can be verified, a higher issue size leads to lower risk premiums whereas a higher maturity leads to higher risk premiums. This is both in line with our expectations.

In column (2), we further include time-varying bond-specific variables. All rating dummies are significant and positive and a lower rating leads to a higher risk premium. In contrast to the regression in column (1), logvolume and maturity are insignificant in this setting. However, term to maturity and the bid-ask-spread now have a positive and significant effect, showing that maturity and liquidity are significant factors influencing risk premiums of mortgage covered bonds. Thus, we can verify similar bond-specific factors influencing risk premiums for mortgage covered bonds as we have previously done for public covered bonds.

4.3.3 Analysis of Macroeconomic Factors and Events

After having examined bond-specific factors, we now want to investigate the effect of macroeconomic factors and several events on risk premiums of mortgage covered bonds. Furthermore, we want to investigate differences in the effects of certain variables between public and mortgage covered bonds. As in the previous chapter, we run fixed effects regressions with the asset swap spread as dependent variable. As in Section 3.4.3, we run the Hausman test to decide between fixed and random effects estimation. The test clearly indicates fixed effects estimation to be superior in our setting.[132] We first examine mortgage covered bonds only. The results are shown in Table 4.8.

We run regressions separately for all mortgage covered bonds (column (1)), only euro-denominated mortgage covered bonds (column (2)), and only non-euro-denominated mortgage covered bonds (column (3)). Regarding variables already shown to influence British, French, German, and Spanish euro-denominated mortgage covered bonds by Prokopczuk and Vonhoff (2012), it can be seen that effects are similar for most variables in each setting. These variables are the rating dummies, bid-ask-spread, LIBOR, stock

[132] As in footnote 87 in the previous chapter, we again investigate the different estimated coefficients obtained by fixed and random effects regressions in more detail. For all time-varying independent variables the coefficients have the same sign and are of similar magnitude and for 12 of the 19 variables, the coefficient obtained by random effects is even contained in the 95% confidence interval of the coefficient estimated using fixed effects. Thus, analogous to the previous chapter, although the differences in the coefficients are statistically significant, as indicated by the Hausman test, their economic relevance seems to be small. Therefore, using random effects estimation in Section 4.3.2 is reasonable.

Table 4.8: **Impact of Macroeconomic Factors and Events on Risk Premiums of Mortgage Covered Bonds.**
This table reports results of fixed effects regressions with asset swap spreads as dependent variable (in bp). The base rating is AAA. Standard errors shown in parentheses are computed using the Huber/White/sandwich estimator of the variance-covariance-matrix and are therefore robust to heteroscedasticity and serial correlation. The symbols *, **, and *** indicate statistical significance at the 5%, 1%, and 0.1% level, respectively.

	(1)	(2)	(3)
Currency	All	Euro	Non-Euro
AA	18.73***	20.06***	6.836
	(3.996)	(4.180)	(10.21)
A	66.21***	70.48***	
	(10.31)	(10.36)	
≤BBB	116.3***	121.7***	
	(16.27)	(16.30)	
NR	1.917	12.70*	-5.442**
	(2.393)	(5.359)	(1.643)
Bid-Ask-Spread	46.94***	47.98***	37.15***
	(4.518)	(4.969)	(4.281)
Term to Maturity	11.79***	12.13***	10.21***
	(0.852)	(1.103)	(1.331)
LIBOR	-0.632	1.368	-5.102***
	(0.828)	(0.875)	(1.467)
Stock Index Return	-0.697***	-0.829***	-0.437***
	(0.0450)	(0.0594)	(0.0462)
Volatility	0.0383	-0.0962	0.174**
	(0.0385)	(0.0523)	(0.0604)
Government Spread	24.84***	24.27***	28.45***
	(5.707)	(5.708)	(4.391)
Unemployment Rate	5.121***	5.542***	3.109
	(0.719)	(0.702)	(2.231)
Debt-GDP-Ratio Difference	1.891***	1.239*	2.689***
	(0.472)	(0.612)	(0.697)
House Price Index Change	-2.139***	-1.726***	-3.385***
	(0.295)	(0.337)	(0.529)
Financial Crisis	24.95***	32.92***	20.00***
	(3.678)	(5.852)	(4.497)
Sovereign Debt Crisis	54.40***	68.73***	29.72***
	(3.772)	(5.462)	(5.246)
CBPP1	6.957*	26.53***	-5.229
	(2.850)	(6.728)	(2.759)
CBPP1_restricted	-41.71***	-54.79***	
	(3.451)	(6.060)	
CBPP2	-1.383	-11.41***	5.435***
	(1.625)	(2.864)	(1.485)
CBPP2_restricted	8.268*	16.09***	
	(3.869)	(4.739)	
Constant	-99.50***	-117.0***	-46.86***
	(10.09)	(11.42)	(12.69)
Observations	177,737	124,715	53,022
R^2 within	0.816	0.836	0.458
R^2 between	0.675	0.771	0.126
R^2 overall	0.732	0.764	0.197

index return, volatility, and house price index change. Thus, we can transfer their findings to a much broader dataset with covered bonds issued in several other countries and currencies.

Regarding further variables shown to influence risk premiums of public covered bonds in the previous chapter, we can also show these variables' effects in the mortgage covered-bond market. The effect of the debt-GDP-ratio difference is particularly noticeable because, as described in the previous chapter, the positive effect of this variable on risk premiums of public covered bonds was, at least partly, attributed to this variable serving as a proxy for the quality of public covered bonds' cover pools. However, as also mentioned in the previous chapter, this variable also describes the macroeconomic situation in a country, and thus, it also influences risk premiums of mortgage covered bonds. The effects of *volatility* and *LIBOR* are only significant in column (3), indicating that non-euro-denominated bonds react stronger to developments of the capital market. Euro-denominated bonds, on the other hand, seem to react stronger to the macroeconomic development, as indicated by the significant effect of *unemployment rate* in column (2).

Further discussion is needed regarding the effects of the two covered bond purchase programs because there exist differences in the effects in the three different settings. For the first program, the pure time dummy has a positive effect in columns (1) and (2), but the dummy restricted on eligible covered bonds has a significant negative effect. This shows, that, when comparing eligible and non-eligible covered bonds, eligible covered bonds have been preferred by investors. However, as the insignificance of *CBPP1* in column (3) indicates, the purchase program did not lead to higher risk premiums of non-eligible mortgage covered bonds when examining such bonds separately.[133] These findings are in line with those obtained for public covered bonds. Regarding the second purchase program, however, the effects are the other way around. A possible explanation might be that during the period of the program, in approximately 89% of the observations related to non-eligible bonds, the rating was AAA, whereas for eligible covered bonds, in only 55% of the observations, the rating was AAA. Although we control for the bond rating,

[133] As already mentioned, covered bonds had to be issued in euros to be eligible for being purchased. Thus, we can neither include CBPP1_restricted nor CBPP2_restricted in column (3).

the difference in risk premiums between covered bonds with different ratings might have been higher during this period, leading to the observed effects.

Further noticeable is the difference in the R^2 overall between columns (2) and (3). The low value in column (3) is a result of the time-constant bond-fixed effects being removed from the model due to the within-transformation in a fixed-effects regression. Since these bond-fixed effects are removed, they cannot be used to calculate estimates of the asset swap spreads. However, these bond-fixed effects are more heterogeneous in the subsample of non-euro-denominated mortgage covered bonds, leading to a smaller fraction of the variance in asset swap spreads that can be explained by the applied model. This shows the importance of the currency as an influencing factor of risk premiums.

Overall, we showed that factors influencing risk premiums are comparable for public and mortgage covered bonds. Against this background, we now want to examine differences in the effects of certain variables. As mentioned above, the debt-GDP-ratio difference could be seen as a proxy for the quality of the cover pools of public covered bonds. Analogously, Prokopczuk and Vonhoff (2012) consider the development of real estate prices in a country a proxy for the quality of the cover pools of mortgage covered bonds. However, both variables also influence risk premiums of the other covered-bond type. Therefore, we repeat the fixed effects regressions for the entire dataset including both covered-bond types and interact these two variables with a dummy variable for mortgage covered bonds. The results are shown in Table 4.9.

The interactions are not significant in each setting, but when they are, they coefficients have the expected negative sign. Thus, there is (light) evidence for a stronger effect of the debt-GDP-Ratio for public covered bonds and for a stronger effect of the house price index change for mortgage covered bonds. This shows that these two variables can indeed, at least partly, be seen as proxies for the quality of the cover pools.

Table 4.9: **Impact of Macroeconomic Factors and Events on Risk Premiums of Both Covered-Bond Types.**
This table reports results of fixed effects regressions with asset swap spreads as dependent variable (in bp). The base rating is AAA. Standard errors shown in parentheses are computed using the Huber/White/sandwich estimator of the variance-covariance-matrix and are therefore robust to heteroscedasticity and serial correlation. The symbols *, **, and *** indicate statistical significance at the 5%, 1%, and 0.1% level, respectively.

	(1)	(2)	(3)
Currency	All	Euro	Non-Euro
AA	14.74***	14.81***	22.80***
	(3.061)	(3.400)	(5.248)
A	69.13***	67.80***	66.29***
	(8.175)	(8.782)	(18.35)
≤BBB	129.8***	123.3***	20.93
	(13.84)	(14.50)	(14.76)
NR	5.522*	10.81*	3.396
	(2.345)	(4.708)	(2.686)
Bid-Ask-Spread	44.67***	52.25***	36.16***
	(3.394)	(4.263)	(3.042)
Term to Maturity	9.918***	9.843***	10.65***
	(0.753)	(0.902)	(1.321)
LIBOR	-1.492*	0.660	-7.323***
	(0.750)	(0.616)	(1.629)
Stock Index Return	-0.718***	-0.766***	-0.503***
	(0.0351)	(0.0410)	(0.0561)
Volatility	0.00186	-0.0906*	-0.0115
	(0.0342)	(0.0372)	(0.0718)
Government Spread	21.36***	22.46***	4.101
	(3.773)	(4.437)	(3.860)
Unemployment Rate	5.212***	5.592***	3.516*
	(0.654)	(0.656)	(1.706)
Debt-GDP-Ratio Difference	2.803***	1.534**	6.094***
	(0.473)	(0.524)	(0.958)
House Price Index Change	-1.191**	-0.279	-2.494***
	(0.380)	(0.405)	(0.609)
Financial Crisis	33.21***	36.22***	48.64***
	(2.818)	(3.807)	(6.612)
Sovereign Debt Crisis	54.53***	60.86***	46.51***
	(3.295)	(4.174)	(5.630)
CBPP1	8.993***	26.21***	-15.12***
	(2.694)	(6.344)	(3.360)
CBPP1_restricted	-40.02***	-47.96***	
	(3.111)	(6.010)	
CBPP2	1.606	-12.41***	12.29***
	(1.773)	(2.788)	(1.828)
CBPP2_restricted	8.226**	18.47***	
	(3.060)	(3.965)	
Debt-GDP-Ratio Difference * Mortgage	-1.320**	-0.580	-4.280***
	(0.439)	(0.443)	(1.141)
House Price Index Change * Mortgage	-0.670	-1.235*	0.126
	(0.455)	(0.484)	(0.810)
Constant	-85.13***	-96.38***	-67.88***
	(8.113)	(9.204)	(14.59)
Observations	250,304	181,482	68,822
R^2 within	0.771	0.810	0.606
R^2 between	0.719	0.821	0.288
R^2 overall	0.735	0.794	0.404

4.4 Interim Results

In this chapter, we examined risk premiums of mortgage covered bonds issued in several different countries and currencies. We transferred previous findings about influencing factors of asset swap spreads of euro-denominated mortgage covered bonds issued in only a few countries to a much broader transnational dataset. Furthermore, we showed that several factors we have shown to influence risk premiums of public covered bonds in the previous chapter also influence mortgage covered bonds in a similar manner. However, we also showed that there exist significant differences in the effects of the debt-GDP-ratio difference and the development of real estate prices between the two covered-bond types. The reason for this is that these two variables have two functions. First, they serve as proxies for the macroeconomic environment in a country and thus, they influence both covered-bond types. Second, however, the debt-GDP-ratio difference can also serve as a proxy for the values of cover pools of public covered bonds since it describes the financial weakness of public sector entities in a country, and the development of real estate prices can serve as a proxy for the values of cover pools of mortgage covered bonds. In line with these functions as proxies for the cover-pool quality, we showed that the first variable has a stronger effect on public covered bonds whereas the second variable has a stronger effect on mortgage covered bonds.

Analogous to the previous chapter, our results can be important for several participants in the international covered-bond market. In particular, they are relevant for issuing banks since they use covered bonds as a refinancing tool and for investors that can use the results in their investment decisions or their risk management processes.

5 The Impact of Credit-Rating Events on Covered-Bond Prices[134]

5.1 Motivation

Following an amendment of a security's rating, investors often react to this rating change, leading to a reaction of the security's price. As shown in Section 2.2, the rating of a covered bond must incorporate both the financial situation of the issuer and the quality of the cover pool, and covered-bond rating methodologies by the major CRAs therefore use an evaluation of the financial strength of the issuer as a starting point. Thus, besides reacting to events regarding the bond rating, covered-bond investors might also react to events regarding the issuer rating.[135] Against this background, we investigate the effects of rating events (down- and upgrades, as well as negative and positive watchlistings) conducted by Fitch and S&P regarding both the bond and the issuer rating on the prices of euro-denominated covered bonds. One would expect significant abnormal price reactions only around rating events regarding the bond rating, since this rating, first, describes the overall quality of the covered bond and, second, often must be used by investors to determine the equity capital that they have to hold for the investment in the

[134] This chapter is mainly based on the working paper „Is the Bond or the Issuer Rating Relevant? The Impact of Credit-Rating Events on Covered-Bond Prices“ which is a joint work with Marc Gürtler (Gürtler and Neelmeier, 2018b). The authors are grateful to the participants of the International Finance and Banking Society 2016 Barcelona Conference and the Southern Finance Association Annual Meeting 2016, Sandestin, for helpful suggestions and comments.

[135] As mentioned in Section 2.2.2, all covered bonds of the same covered-bond program have the same credit rating but we will nevertheless use the terminology '(covered-)bond rating' instead of 'covered-bond program rating' in the following.

covered bond, as discussed in Section 2.3. However, we find significantly negative price effects of downgrades and negative watchlistings for both rating types. With respect to the issuer rating, significant effects can even be verified around positive events. In addition to examining the strength of abnormal price reactions around rating events, we further investigate influencing factors of the intensity of the abnormal price reactions around downgrades of the two rating types.

The standard method to investigate the effects of rating events is the event study. In this way, several studies to date have investigated various asset classes, such as stocks,[136] government bonds,[137] corporate bonds,[138] credit default swaps,[139] and convertible bonds.[140] The empirical results in these studies are mixed. In most studies, however, it has been shown that negative rating events – that is, downgrades or negative watchlistings – have a significant negative effect on security prices, whereas a significant effect can be verified for positive rating events only rarely. However, no study to date has investigated the direct impact of rating events on covered-bond prices. Because the cover pool serves as collateral in case of the insolvency of the issuer, it might well be that, if any, effects of bond-rating events are considerably less intense for covered bonds than for other asset classes, and issuer-rating events may be expected to have no effect at all.

Against this background, we extend the existing literature regarding the effects of rating events on capital markets by investigating the effects on the prices of euro-denominated covered-bonds using state-of-the-art event-study methods. As we have shown in the previous two chapters, the rating of a covered bond influences the risk premiums of covered bonds, which is also supported by other studies in the literature.[141] For the German market, Prokopczuk et al. (2013) also find an influence of the issuer rating. However, thus far, neither the immediate impact of a rating event regarding the bond rating nor regarding the issuer rating has been investigated, and we fill this gap in the literature.

[136]See e.g., Holthausen and Leftwich (1986); Goh and Ederington (1993); Norden and Weber (2004).
[137]See e.g., Cantor and Packer (1996); Afonso et al. (2012).
[138]See e.g., Hand et al. (1992); Steiner and Heinke (2001); May (2010). For an extensive literature review on event studies concerning corporate bonds, see Maul and Schiereck (2017).
[139]See e.g., Hull et al. (2004); Norden and Weber (2004); Galil and Soffer (2011); Finnerty et al. (2013).
[140]See Hundt et al. (2016).
[141]See e.g., Packer et al. (2007); Prokopczuk and Vonhoff (2012); Prokopczuk et al. (2013).

As Ederington et al. (2015) note, bond markets exhibit considerable heteroscedasticity, but most bond market event studies do not account for this factor, apart from investigating effects separately for investment-grade and speculative-grade securities. We seize suggestions by these authors and by Bessembinder et al. (2009) to directly take heteroscedasticity into account by using the matching portfolio model with regard to different rating categories and maturity groups to compute abnormal returns, by using the firm-level approach to calculate abnormal returns for entire covered-bond programs, and by standardizing abnormal returns based on their their standard deviation. In line with literature focusing on other asset classes, our results show that negative rating events regarding bond ratings lead to significantly negative abnormal returns but that positive rating events induce no or only small positive reactions. We show that, despite specifically controlling for the heteroscedasticity of abnormal returns, the effects are most intense when the rating is changed from investment to speculative grade. This results can probably be explained at least partly by regulatory requirements for different groups of covered-bond investors, as described in Section 2.3. We further show that not only negative events regarding bond ratings but also negative events regarding issuer ratings lead to significantly negative abnormal returns, which indicates that investors also incorporate such ratings into their trading decisions.

The remainder of the chapter is organized as follows. In the next section, we discuss possible effects of rating events on covered-bond prices that we aim to examine empirically. In the third section, we describe the methodology used, and in the fourth section, we introduce our dataset. In the fifth section, the results of our empirical analyses are presented, before we conclude and summarize the results in the final section.

5.2 Research Question

As mentioned in the introduction, the main research question that we want to investigate in this chapter reads as follows:

> *What effect do rating events regarding the bond or the issuer rating have on covered-bond prices?*

In this section, we discuss this research question in more detail. More precisely, we discuss potential reasons for the existence or absence of significant effects of different rating events on covered-bond prices.

The impact of credit-rating events on securities' prices has already been investigated for several other asset classes, as mentioned in the previous section. However, as covered bonds exhibit 'a unique combination of risk exposures'[142] owing to the dependence of the bond's quality of both the issuer's financial situation and the composition of the cover pool, price reactions around rating events might be different in this asset class. Furthermore, because of the connection between bond ratings and issuer ratings, we can investigate and compare the effects around rating events for both bond ratings and issuer ratings.

If the market for a security rated by an external rating agency is efficient in the semi-strong form according to Fama (1970), following an announcement of a rating event (i.e., a rating change or a placement on the watchlist), two possibilities may arise: (1) either the rating event brings new information to the market and should therefore lead to a significant abnormal movement of the security's price or (2) the information leading to the rating event has already been incorporated into the price, leading to no significant price reaction. However, if a rating event has no measurable effect on the security's price, this can also indicate a lack of efficiency of the security's market. Concerning the effect of rating events on security prices for other asset classes, Norden and Weber (2004) show in an extensive literature review that most studies investigating stock and bond markets find significant price reactions after downgrades but weaker or even no reactions after upgrades. Regarding bond markets, however, owing to limited data availability, most of the illustrated studies investigate only monthly or weekly prices. Reactions of daily prices are investigated by, for example, Steiner and Heinke (2001) and May (2010). While Steiner and Heinke (2001) support the general findings of significant price reactions after downgrades but no reactions after upgrades, May (2010) indeed finds significant

[142] See Forster and Purwin (2014)

reactions of corporate bond prices after both down- and upgrades. The price reaction is considerably less pronounced after upgrades compared with downgrades, though, and it is driven mainly by upgrades of speculative-grade rated bonds. For investment-grade rated corporate bonds, May (2010) cannot verify statistically significant abnormal price reactions after upgrades. Reasons for this non-uniform behavior by investors might be information-processing biases or asymmetric risk aversion by attaching more weight to bad news than to good news.[143] Furthermore, investors might be forced to sell a bond after a downgrade if the new rating is lower than permitted by (internal or external) regulations. After an upgrade, on the other hand, investors are not forced to buy the bond but it might only become part of the universe of investable bonds. As nearly every rated covered bond has an investment-grade rating and as the majority of covered bonds even have an AAA-rating,[144] this asymmetric price adjustment can also be expected to hold for covered bonds. However, because of the dual recourse of investors in case of insolvency of the issuer, it might even be the case that independent of the specific bond rating, investors consider the default risk of covered bonds to be so small that they do not react to rating events at all. Therefore, we want to examine the effects of downgrades and upgrades of bond ratings on covered-bond prices.

In addition to upgrades and downgrades, credit rating agencies further have the possibility to place ratings on watchlists.[145] Such watchlistings are conducted when a rating agency sees an increased probability for a potential rating change in the short-term and they can either be negative (indicating a potential downgrade), positive (indicating a potential upgrade), or developing (indicating a potential rating change without a predefined direction). In previous studies, asymmetric price reactions after negative and positive watchlistings have been shown and substantiated analogously to the asymmetric price reactions after up- and downgrades.[146] Covered-bond prices can be expected to react (or not react) to watchlistings in a similar way as to rating changes. If prices do

[143] See Dichev and Piotroski (2001); Norden and Weber (2004).
[144] See Melms and Schulz (2013) or Tables 3.2 and 4.2 in the previous chapters.
[145] S&P calls a rating to be on 'CreditWatch', see Standard&Poor's (2016), and Fitch calls ratings to be on 'Rating Watch', see Fitch (2017). For didactic reasons, we call these events 'watchlistings' in the following, independent of the specific credit rating agency.
[146] See Steiner and Heinke (2001); Norden and Weber (2004); Hull et al. (2004).

react to rating events, significantly negative price reactions can be expected for negative watchlistings.[147] Moreover, since a negative watchlisting indicates a potential downgrade in the short-term and since both negative watchlistings and downgrades might have a significant impact on covered-bond prices, there might be differences between the effect of downgrades with a prior negative watchlisting and downgrades without a prior watchlisting. In the first case, the downgrade might have been expected by market participants leading to (the majority of) the abnormal price reaction having already occurred around the watchlisting. For downgrades without a prior watchlisting, however, market participants might have been more surprised by the event, leading to stronger price reactions. Against this background, we want to examine the effects of negative and positive watchlistings on covered-bond prices, as well as the effects of both expected and unexpected downgrades.

As mentioned in Section 2.2, covered-bond rating methodologies of different credit rating agencies all have an evaluation of the financial strength of the issuer as a starting point. Therefore, we also investigate the effects of rating events with respect to issuer ratings. At first glance, if any, one would expect only effects of bond-rating events on covered-bond prices to exist but no effects of issuer-rating events, as the bond rating describes the overall quality of a covered bond and as it is crucial for regulatory requirements. However, for the German market, Prokopczuk et al. (2013) show an influence of the issuer rating on risk premiums of covered bonds in their regression model. They do not investigate the immediate effect of a rating event regarding the issuer rating on covered-bond prices, but since they show an influence of the issuer rating on risk premiums of covered bonds, covered-bond investors might also react to negative rating events regarding issuer ratings. Possible reasons for abnormal price reactions around negative issuer-rating events might be that, on one hand, at least the probability of a future negative event of the covered-bond rating might have increased in the course of this, and, on the other, in a first step, the financial situation of the issuer is crucial for the claims of the investors to be fulfilled. The evaluation of this situation may have then worsened when there is

[147] There are only very few positive or developing watchlistings in our employed dataset. Thus, we cannot investigate corresponding effects.

a negative issuer-rating event. For positive events regarding the issuer rating, however, analogous to the bond rating, we do not expect a significant reaction of covered-bond prices. Against this background, we want to examine the effects of issuer-rating events on covered-bond prices.

Finally, after having examined abnormal price reactions around rating events, we further want to investigate what factors influence the intensity of abnormal price reactions. Possible differences in the magnitude of the abnormal price reaction might occur for rating events conducted by the two different rating agencies, if the covered bond is a multi-issuer Cédula, or for different types of collateral in the cover pool, for example.

5.3 Methodology

In this section, we briefly present the methodology that we use to examine the immediate effects of rating events on covered-bond prices. Generally, we incorporate a standard event-study methodology, as described in Campbell et al. (1997), for example.[148] According to Campbell et al. (1997), Dolley (1933) perhaps conducted the first published study using this methodology, and since then, a large number of studies have used this methodology to investigate the effects of specific events on the prices of securities, most often common equity. In several studies, this methodology has also been used to investigate bond markets. However, in recent years, the adequate utilization of event studies regarding bond markets has been the subject of various scientific studies. To take these recent insights into account, we consider the results of Bessembinder et al. (2009) and Ederington et al. (2015) regarding the method of calculating abnormal returns, dealing with multiple bonds of the same covered-bond program, and considering heteroscedasticity.

We treat the day of a rating event k as event day $t = 0$, and the event period lasts from day $t = -5$ to day $t = 5$ (called the $[-5, 5]$-event period). We use clean events in such a way that event periods of the same event type of the same credit rating agency are not allowed to overlap. If this is the case, only the first event is considered. We do not

[148]See Section 5.7.1 in this chapter's appendix for an overview of the general structure of an event study.

account for possible ‘contaminating’ events as other authors do,[149] since we are interested in the effects of rating events in general, regardless of whether there is other news about the covered bonds or the issuing financial institutions in the event period. For each of the days t in the event period, we calculate the return $R_{i,t}$ of each bond i of the covered-bond program that is affected by the considered rating event as

$$R_{i,t} = ln(P_{i,t}/P_{i,t-1}), \quad t \in \{-5, -4, ..., 5\}, \tag{5.1}$$

with $P_{i,t}$ being the price of covered bond i on day t. We do not consider accrued interest since both Bessembinder et al. (2009) and Ederington et al. (2015) find that the impact on test size and power is negligible. We further use continuous returns rather than discrete returns because we want to investigate cumulative abnormal returns, which is economically more reasonable for continuous returns. Furthermore, for all return calculations in our dataset, the following statement holds. If a bond does not trade on day t, we cannot calculate returns for both day t and day $t+1$. Therefore, we do not have a return observation for these two days in such a case. We do not calculate a two-day-return from day $t-1$ to day $t+1$ or anything similar; we simply drop these (missing) observations from the dataset.

Then, we calculate abnormal bond returns

$$ABR_{i,t} = R_{i,t} - BMR_{i,t}, \quad t \in \{-5, -4, ..., 5\}, \tag{5.2}$$

with $BMR_{i,t}$ being the benchmark returns, which are calculated by applying the matching portfolio model recommended by Bessembinder et al. (2009) and confirmed by Ederington et al. (2015). Therefore, for days $t = -5$ to $t = 5$, we calculate the bond returns for all bonds from covered-bond programs not affected by the rating event that are in the same rating class and maturity group as bond i on day $t = -1$ – that is, one day before the rating event. We further restrict these covered bonds to not exhibit a rating event during the event period. Then, we combine these matching bonds in a portfolio and use the average of these returns as the benchmark return. We classify the covered bonds with

[149]See e.g.,May (2010).

regard to the Fitch rating and use the S&P rating if there is no Fitch rating. We use five rating classes (AAA, AA, A, BBB, and ≤BB) and three maturity buckets (1-3 years, 3-7 years, and >7 years). Only for the rating class ≤BB do we not separate the maturity buckets 3-7 years and >7 years owing to the existence of otherwise too few observations. Our maturity groups differ slightly from those employed in the mentioned studies since the average term to maturity is smaller in our dataset.

By using rating/maturity-matched portfolios as benchmarks, we have mitigated two main causes for heteroscedasticity in bond markets. However, as shown by Ederington et al. (2015), standard deviations of abnormal bond returns are still severely heterogeneous in the different rating/maturity groups. Therefore, we also calculate $R_{i,t}$, $BMR_{i,t}$, and, consequently, $ABR_{i,t}$ for days $t = -104$ to $t = -6$ (i.e., using prices from the 100-day estimation period $t = -105$ to $t = -6$). Then, we estimate the standard deviation $\sigma_{i,k}$ of abnormal bond returns in the estimation period and divide each abnormal bond return in the event period by the obtained estimate, leading to standardized abnormal bond returns:[150]

$$SABR_{i,t} = \frac{ABR_{i,t}}{\sigma_{i,k}}, \quad t \in \{-5, -4, ..., 5\}. \tag{5.3}$$

If there are $n > 1$ covered bonds in a covered-bond program j (which is typically the case), we do not treat a rating event as a separate observation for each of these bonds. Instead, we use the firm-level-approach, as proposed by Bessembinder et al. (2009) and Ederington et al. (2015), and calculate one standardized abnormal return for the entire

[150] Ederington et al. (2015) use two estimation periods to calculate the standard deviation of abnormal returns: one before and one after the event period. However, they state that, because of the event, the firm (or in our case, the covered bond) can be changed in some way so that volatility after the event is not representative of volatility at the time of the event. In such cases, a longer estimation period prior to the event period should be used. We think that a rating event can indeed change the volatility of a covered bond, and thus, we use a pure pre-event estimation period. Furthermore, they base their analyses on two-day returns from day $t = -1$ to day $t = 1$. However, because we want to analyze different parts of the event period with different lengths, we use one-day returns and cumulate these afterwards. Consistent with their recommendation, we restrict benchmark bonds to have at least six returns during the estimation period.

program as the average of each standardized abnormal bond return weighted by the issue sizes of the individual covered bonds:

$$SAR_{j,t} = \sum_{i=1}^{n} SABR_{i,t} \cdot \omega_i, \quad t \in \{-5, -4, ..., 5\}, \tag{5.4}$$

where ω_i is the fraction of bond i's issue size of the sum of all bonds' issue sizes in the covered-bond program j. To be able to compare our results with existing studies, we also calculate abnormal returns for the covered-bond programs without standardization:

$$AR_{j,t} = \sum_{i=1}^{n} ABR_{i,t} \cdot \omega_i, \quad t \in \{-5, -4, ..., 5\}. \tag{5.5}$$

To examine the anticipation effects, immediate impact, and subsequent effects of a rating event separately, we split the event period in three sub-periods: $[-5, -1]$, $[0, 1]$, and $[2, 5]$. We use $[0, 1]$ instead of simply $t = 0$ to measure the immediate impact because we do not know whether the announcements of the rating events occur before or after the point in time that the bond prices on the event days are fixed. For each of these sub-periods, we calculate the cumulative standardized abnormal returns and cumulative abnormal returns for every covered-bond program affected by a rating event. To test the significance of the impacts, we apply the parametric one-sided t-test with the null hypothesis that the mean (standardized) abnormal return is greater than or equal to zero for negative events and less than or equal to zero for positive events. We further apply the non-parametric one-sided signed-rank test and sign test, both with analogous null hypotheses as the t-test. However, the difference is that these tests examine the median (standardized) abnormal return instead of the mean.[151]

After examining the effects of rating events using the event-study methodology described above, we further investigate the influencing factors of the abnormal price reaction around rating events. Therefore, we perform cross-sectional OLS regressions with (standardized) abnormal covered-bond program returns in the $[0, 1]$-period as the dependent variable.

[151] See Section 5.7.2 in this chapter's appendix for details about the three different tests.

5.4 Data

In this section, we illustrate the dataset that we use in our empirical analyses. Therefore, we begin by describing the sampling procedure and the type of data that we obtained. Afterward, we present several descriptive statistics to impart deeper insights. This step is important with regard to the interpretation of the results of the empirical analyses.

5.4.1 Sample Selection

As in the previous two chapters, we again use Bloomberg as our primary data source. We extract every bond labeled as 'covered', 'Pfandbriefe' or 'Jumbo Pfandbriefe' that has a maturity date after 31 December 2005 and that is denominated in euros. For these bonds, we obtain daily pricing quotes for the period from January 2006 to December 2014 and calculate continuous daily returns.[152] We delete all covered bonds with fewer than 100 daily prices or fewer than 10 daily returns, as recommended by Ederington et al. (2015), and we exclude floating-rate notes. After these data cleaning operations, the dataset consists of 2,063 covered bonds. For these bonds, we obtain time-constant descriptive data, such as the issuer, issue size, and type of collateral. Furthermore, we obtain historic bond ratings by Fitch and S&P from Bloomberg. Unfortunately, we know no possibility to directly retrieve information regarding the covered-bond program to which a covered bond belongs. Therefore, we filter our dataset into issuer/collateral-type combinations to obtain a starting point for the assignment of the covered bonds to covered-bond programs. Then, we examine whether the rating histories of all covered bonds in each of these combinations are the same. The majority of the covered bonds can thus be attributed to a specific covered-bond program. If the historical ratings do not coincide or if, for some of the covered bonds, there is no rating history available from Bloomberg, we use publicly available information on the websites of the issuers, other websites, and from Nord/LB

[152]We use 'Bloomberg Generic' (BGN) prices. According to the Bloomberg help page, these are market consensus prices calculated by using prices that have been contributed to Bloomberg. Notably, Bloomberg does not act as a market maker and if no consensus price can be assigned a security, it will be marked 'not priced'.

(2016) to check whether the issuers have more than one covered-bond program with the same type of collateral or whether there are other reasons for the differing rating histories. For example, some issuers have changed their names or merged with other financial institutions and thereby also merged their covered-bond programs since the issuance of some of the covered bonds in the dataset, leading to (partly) different rating histories for some covered bonds from the same issuer with the same collateral type. In such cases, we try to reconstruct the histories of the issuing financial institutions again by using publicly available information. For most of the covered bonds, we are able to attribute them to a specific covered-bond program, and some of them have even changed the covered-bond program during the considered time period because the issuer was merged with another financial institution. For 13 covered bonds, however, we are not able to unequivocally attribute them to a specific covered-bond program, and we therefore exclude them from the dataset. We exclude them because a consideration as separate covered-bond programs would have led to an overly strong impact of these bonds on the overall results. Further exclusion of ten bonds without information on the type of collateral and 15 bonds without information about the issue size reduces the final dataset to 2,025 covered bonds from 299 covered-bond programs (including 58 Spanish multi-issuer Cédulas[153]), issued in 22 different countries. Of these, 111 covered bonds from five covered-bond programs change the covered-bond program during the considered period. For all covered-bond programs, we further retrieve the ratings of the issuing financial institutions ('issuer ratings' in the following) for the two rating agencies, when obtainable. Since there are several ratings with respect to a specific financial institution, we apply the priority rules used by Norden and Weber (2004) to decide which rating to use. After excluding observations for which the term to maturity is less than one year, our sample consists of 1,314,637 daily returns, and for 1,075,394 of these observations, there exists a rating of the covered-bond program by at least one of the two agencies.

[153] In contrast to covered bonds from the same covered-bond program, different multi-issuer Cédulas cannot be combined since they all have different backing portfolios and thus have individual rating histories.

5.4.2 Descriptive Statistics

The distribution of the covered-bond programs with regard to the country of issuance is presented in Table 5.1.

Table 5.1: **Summary Statistics: Distribution of Covered-Bond Programs by Country of Issuance.**
This table shows the distribution of the number of covered-bond programs with regard to the country of issuance.

	Number	%		Number	%
Australia	4	1.34	**Italy**	14	4.68
Austria	20	6.69	**Luxembourg**	3	1.00
Belgium	3	1.00	**Netherlands**	6	2.01
Canada	7	2.34	**New Zealand**	4	1.34
Denmark	2	0.67	**Norway**	4	1.34
Finland	6	2.01	**Portugal**	8	2.68
France	23	7.69	**Spain**	90	30.10
Germany	75	25.08	**Sweden**	6	2.01
Greece	1	0.33	**Switzerland**	2	0.67
Hungary	2	0.67	**UK**	11	3.68
Ireland	6	2.01	**US**	2	0.67

Most of the covered-bond programs come from Spain and Germany.[154] The next largest shares of programs are issued in France, Austria, Italy, and the UK, which is generally in line with statistics about the international covered-bond market.[155]

In Table 5.2, we present the number of daily bond return observations in our dataset separately for each of the rating/maturity groups that we use to calculate abnormal returns. It can be stated that, the worse the rating class, the fewer returns are available in the dataset. As described in Section 2.2, the average covered-bond ratings are higher than the average unsecured corporate bond ratings, which is in line with our dataset. In the vast majority of cases (67%), the rating belonging to a return is AAA, compared to

[154] The high percentage of Spanish programs is affected, among other things, by the high number of multi-issuer Cédulas.
[155] See (ECBC, 2016, Ch. 5)

Table 5.2: **Summary Statistics: Distribution of Returns by Rating Class and Maturity Group.**
This table shows the distribution of the number of bond returns in the dataset by rating class and maturity group.

	AAA	AA	A	BBB	≤BB	NR	Total
1-3	292,130	41,000	20,294	13,590	853	94,029	461,896
3-7	382,537	45,697	22,208	15,167	2,130	111,329	579,068
>7	204,126	20,258	6,534	8,869		33,885	273,672
Total	878,793	106,955	49,036	37,626	2,983	239,243	

only 6.9% of observations having an AAA- or AA-rating in the corporate bond dataset used by Ederington et al. (2015), for example.

The distribution of pre-event ratings regarding the covered-bond ratings and the issuer ratings is presented in Table 5.3. Panel A shows the pre-event ratings concerning bond ratings. The high quality of the asset class can be seen in the very good average pre-event ratings. For example, in almost 69% of downgrades, the pre-event rating is AAA or AA. Concerning the two credit rating agencies, there are more negative watchlistings and upgrades related to S&P than to Fitch, but more downgrades and positive watchlistings related to Fitch than to S&P.[156] Regarding the type of event, negative events clearly dominate the dataset. Negative watchlistings occur with the highest frequency, followed by downgrades, upgrades, and positive watchlistings. This order generally holds for both agencies; for Fitch, however, there are more downgrades than negative watchlistings.

Panel B shows the pre-event ratings concerning issuer ratings. Because we are not able to obtain issuer ratings for all covered-bond programs with a covered-bond rating and especially due to the high number of multi-issuer Cédulas, which are issued by a separate fund without legal status,[157] and therefore do not have an issuer rating, we have slightly fewer rating events for issuer ratings than for bond ratings. However, for downgrades of bond ratings, for example, more than half of the events belong to multi-issuer Cédulas. As events regarding issuer ratings can be observed only for other covered bonds, for such

[156] There are only seven positive watchlistings in our dataset. Thus, as mentioned in footnote 147, we cannot investigate the effect of positive watchlistings of bond ratings because there are too few observations.

[157] See Garcia Muñoz (2009).

Table 5.3: **Summary Statistics: Distribution of Pre-Event Ratings by Rating Agency and Event Type.**
This table shows the distribution of pre-event ratings with regard to the credit rating agency and the type of the event concerning both bond- and issuer-rating events.

Panel A:	**Bond Ratings**					
	Downgrades			**Upgrades**		
	Fitch	**S&P**	**Total**	**Fitch**	**S&P**	**Total**
AAA	72	70	142	-	-	-
AA	72	42	114	7	9	16
A	42	36	78	5	11	16
BBB	8	27	35	13	8	21
≤BB	-	3	3	3	1	4
Total	194	178	372	28	29	57
	Negative Watchlistings			**Positive Watchlistings**		
	Fitch	**S&P**	**Total**	**Fitch**	**S&P**	**Total**
AAA	77	116	193	-	-	-
AA	67	28	95	3	-	3
A	7	36	43	1	1	2
BBB	2	40	42	1	1	2
≤BB	1	4	5	-	-	0
Total	154	224	378	5	2	7

Panel B:	**Issuer Ratings**					
	Downgrades			**Upgrades**		
	Fitch	**S&P**	**Total**	**Fitch**	**S&P**	**Total**
AAA	2	1	3	-	-	-
AA	36	25	61	-	6	6
A	60	101	161	11	39	50
BBB	19	49	68	12	13	25
≤BB	2	32	34	2	8	10
Total	119	208	327	25	66	91
	Negative Watchlistings			**Positive Watchlistings**		
	Fitch	**S&P**	**Total**	**Fitch**	**S&P**	**Total**
AAA	1	-	1	-	-	0
AA	10	6	16	-	-	0
A	21	53	74	10	5	15
BBB	11	24	35	1	6	7
≤BB	2	16	18	-	2	2
Total	45	99	144	11	13	24

covered bonds, there are even considerably more issuer-rating events than bond-rating events.

As a consequence of the financial strength of the issuer being the starting point for the derivation of the covered-bond rating, the average pre-event rating is lower than that for bond ratings. The distribution of the different types of issuer-rating events is slightly different than that for bond-rating events. For issuer ratings, downgrades occur with the highest frequency, followed by negative watchlistings, upgrades, and positive watchlistings, and this order holds for both rating agencies.

Finally, we present the number of events by country and event type for the bond rating in Table 5.4. The slightly lower total number of downgrades in Table 5.4 compared with Table 5.3 results from rating actions by both rating agencies on the same date. These events will be treated as only one event in the following. For each event type, most observations come from Spain, which is in line with Spanish covered-bond programs accounting for 30% of the dataset, as shown in Table 5.1. However, as mentioned in the explanation of Table 5.3, this is driven mainly by the high number of multi-issuer Cédulas, which account for 215 of the 256 downgrades in Spain, for example. The remaining 41 downgrades of Spanish covered bonds are still considerably more than the 28 downgrades of Portuguese covered bonds and the 27 downgrades of Italian covered bonds, which are the second- and third-highest fractions of the dataset. Portuguese covered-bond programs account for less than 3% of the dataset, however, and Italian covered bonds account for less than 5% of the dataset. For German covered-bond programs, on the other hand, which account for 25% of the dataset, the number of events is considerably lower, indicating a higher quality of German Pfandbriefe over Spanish Cédulas as well as Portuguese and Italian covered bonds. In six countries with only a few covered-bond programs, there is no event in the entire dataset. Covered bonds from these countries and other covered bonds without any rating event are therefore used only to calculate the benchmark returns in the abnormal return calculation.

Table 5.4: **Summary Statistics: Number of Bond-Rating Events by Country and Event Type.**
This table shows the distribution of the number of bond-rating events with regard to the country and the type of the event.

	Downgrades	Upgrades	Negative Watchlistings	Positive Watchlistings
Australia	–	–	–	–
Austria	–	–	–	–
Belgium	–	–	–	–
Canada	–	–	1	–
Denmark	–	–	1	–
Finland	–	–	1	–
France	11	3	20	–
Germany	15	2	48	–
Greece	4	3	3	1
Hungary	–	–	–	–
Ireland	10	2	11	
Italy	27	2	12	1
Luxembourg	4	–	4	–
Netherlands	3	–	5	–
New Zealand	–	–	–	–
Norway	–	–	1	–
Portugal	28	4	24	–
Spain	256	39	230	5
Sweden	–	–	3	–
Switzerland	–	–	–	–
UK	2	1	8	–
US	10	1	6	–
Total	370	57	378	7

5.5 Empirical Results

In this section, we present the results of our empirical analyses. In the first subsection, we investigate the effects of rating events by using the event-study methodology as described in Section 5.3. In the second subsection, we investigate the influencing factors of abnormal price reactions around rating events by using cross-sectional regressions. In the third subsection, we present several robustness checks of the results obtained in the previous two subsections. Finally, in the fourth subsection, we compare our results to those obtained by studies focusing on other asset classes and discuss the intensity of abnormal price reactions around rating events.

5.5.1 Effects of Rating Events

Before we investigate average cumulative standardized abnormal returns (SARs in the following) and average cumulative absolute abnormal returns (ARs in the following) of the covered-bond programs for different event types in terms of statistical significance in the $[-5, 5]$-event period, we want to examine SARs and ARs around upgrades and downgrades of bond ratings graphically in the event period, as presented in Figure 5.1.

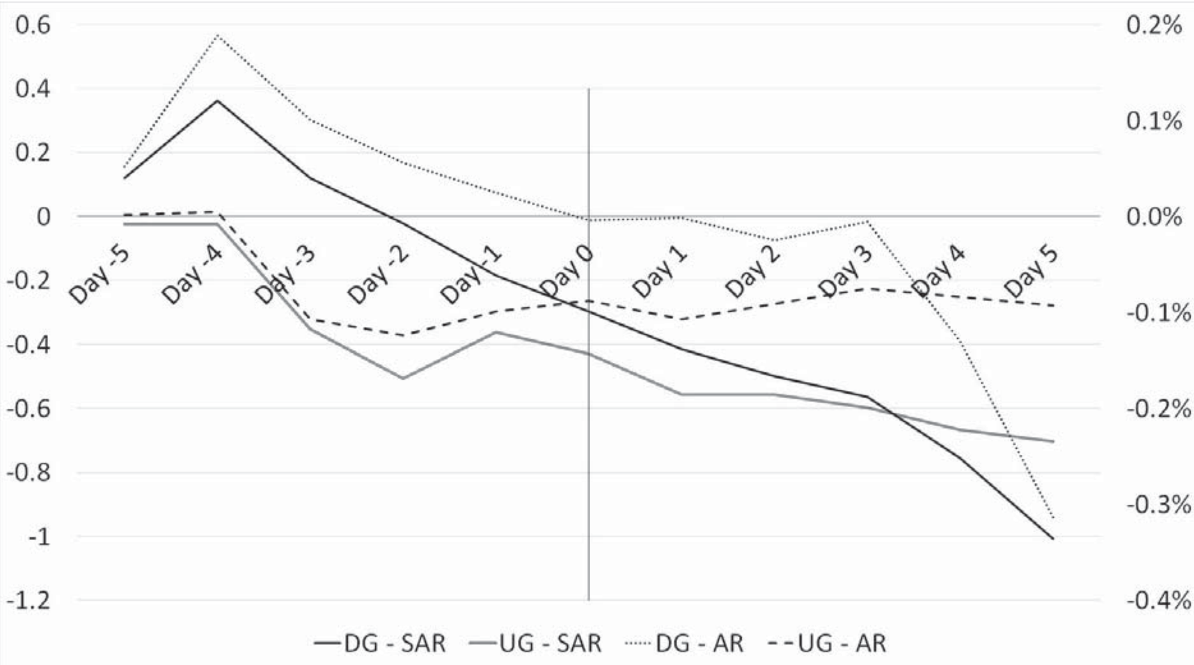

Figure 5.1: **SARs and ARs for Up- and Downgrades of the Bond Rating.** This figure shows SARs and ARs for up- and downgrades of the bond rating, respectively, during the period from 5 days before the rating event to 5 days after the rating event. SARs are measured in units of standard deviation (left-hand scale), ARs are measured in percentage points (right-hand scale). The solid, vertical line denotes the event day.

For downgrades, SARs and ARs are positive on the first days of the event period. On subsequent days, however, abnormal returns decrease almost steadily until the end of the event period, indicating negative price reactions around downgrades, as expected. For upgrades, however, there are negative abnormal returns prior to the event but nearly no abnormal returns directly before the event or in the period following the event. The negative abnormal returns prior to upgrades are surprising, since no price reactions would have been expected, or, if any, they would be positive. However, May (2010) also finds negative abnormal returns of corporate bonds prior to upgrades at least in some subsamples (especially when restricting the sample to investment grade). Although he does not give an explanation for the effect, it is thus not completely unknown in the literature.

To investigate whether abnormal price reactions around upgrades and downgrades of bond ratings can indeed be verified, we need to look at the results of significance tests concerning SARs/ARs for these two types of events, which can be found in Table 5.5.

Table 5.5: **Effect of Bond-Rating Changes on Covered-Bond Prices.** This table reports the numbers of events, average covered-bond program SARs and ARs around upgrades and downgrades of bond ratings, and significance of the t-test, the signed-rank test, and the sign test. Statistical inference is based on SARs (left-hand side of a cell) and ARs (right-hand side of a cell), respectively. Results are presented separately for downgrades and upgrades of both credit rating agencies (Panel A) and for rating changes of each credit rating agency (Panel B), respectively. Results are further presented separately for different sub-periods of the event period. The symbols *, **, and *** indicate statistical significance at the 5%, 1%, and 0.1% level, respectively, and significance levels are based on one-sided tests.

		Downgrades			Upgrades		
		[-5,-1]	[0,1]	[2,5]	[-5,-1]	[0,1]	[2,5]
Panel A:							
	Obs.	370	370	370	57	57	57
	SAR	-0.1489	-0.2376	-0.5818	-0.3607	-0.1939	-0.1466
Both Rating Agencies	AR	0.03%	-0.03%	-0.31%	-0.10%	-0.01%	0.01%
	t-test		**	*** ***			
	Sign rank		*	** ***			
	Sign test			** **			
Panel B:							
	Obs.	194	194	194	28	28	28
	SAR	0.1111	-0.0875	-0.4814	0.0164	-0.2881	-0.1332
Fitch	AR	0.07%	0.04%	-0.40%	0.06%	-0.02%	0.04%
	t-test			* ***			
	Sign rank			*			
	Sign test						
	Obs.	178	178	178	29	29	29
	SAR	-0.4755	-0.3884	-0.6953	-0.7249	-0.1030	-0.1596
S&P	AR	-0.02%	-0.10%	-0.22%	-0.25%	0.01%	-0.01%
	t-test	**	*** *	*** ***			
	Sign rank	**	*** **	*** ***			
	Sign test		** *	** **			

The result tables in this subsection all have the same structure. In the first row, the type of event is specified, and in the second row, the sub-event periods are shown. In the first column, possible restrictions on the dataset are presented. In the additional cells, the number of observations,[158] the SARs in units of standard deviation, and the ARs in percentage terms are shown. Below, we present the significance of the three tests applied to both SARs and ARs separately. Asterisks on the left-hand side of a cell indicate significance of SARs, whereas asterisks on the right-hand side concern ARs. As a rule, we consider SARs/ARs to be significant when at least two of the three tests reject the corresponding null hypothesis.

In Panel A of Table 5.5, we investigate downgrades and upgrades by both rating agencies. It can be seen that significant abnormal price reactions can indeed be verified around downgrades. While there are no anticipation effects, SARs are negative and significant in both the $[0,1]$- and the $[2,5]$-period and ARs are negative and significant in the $[2,5]$-period. Thus, the market does not anticipate downgrades but reacts at the time of the event. Furthermore, even several days after the event, downgraded covered bonds perform worse than the benchmark bonds. For upgrades, however, we cannot detect significant abnormal price reactions in any of the sub-periods. These results are in line with most literature on other asset classes. Thus, although the cover pool collateralizes the covered bond, investors indeed react to downgrades of the bond rating. However, the magnitude of the effects seems to be rather low for covered bonds. We will discuss this issue in more detail in Section 5.5.4.

We further investigate the impact of downgrades and upgrades for each of the two rating agencies separately, as shown in Panel B of Table 5.5. For upgrades, we can still see no evidence of significant abnormal price reactions, whereas for downgrades, the results are less clear in this setting. For S&P, the abnormal price reactions around downgrades can be confirmed. We observe significant SARs in each of the three sub-periods and significant ARs at least in the $[0,1]$- and the $[2,5]$-sub-period. For Fitch, on the other hand, abnormal

[158] We include only events, for which we can compute SARs for each sub-period (i.e., there have to be enough observations in the rating/maturity-matched portfolio to calculate abnormal returns in the entire event period and to estimate the standard deviation of abnormal returns in the estimation period).

returns are significant only for the sub-period after the downgrade. Altogether, however, we can still verify significant abnormal price reactions around downgrades.

Next, we want to examine the effect of the placement of a covered-bond program's rating on a (negative or positive) watchlist. The belonging results are presented in Table 5.6.[159]

Regarding negative watchlistings, we see a similar behavior of abnormal returns, as around rating changes, as shown in Panel A. SARs and ARs are significantly negative in both the $[0, 1]$- and the $[2, 5]$-period. In the $[-5, -1]$-period, however, only the t-test shows significant abnormal price reactions. To investigate the effects of a negative watchlisting in more detail, we split the observations for downgrades into two subsamples: one in which the rating has been on the negative watchlist before the downgrade (expected downgrades) and one in which there has been no such watchlisting before (unexpected downgrades). In Panels B and C, the results for expected and unexpected downgrades are shown. Noticeably, the numbers of observations in the two subsamples are quite different. There are more than twice as many expected downgrades as unexpected ones. Regarding the impacts, there are noticeable differences between the two types of events. Unexpected downgrades lead to highly significant abnormal price reactions in the $[2, 5]$-period, whereas for expected downgrades, statistical significance can be observed only for SARs in the $[0, 1]$-period. A possible reason for the limited significance of abnormal price reactions around expected downgrades might be that in addition to the negative effect around the downgrade, there has already been a negative effect around the date of the negative watchlisting, as shown in Panel A.

[159] As already mentioned in footnotes 147 and 156, there are too few positive watchlistings in the dataset to investigate potential corresponding abnormal price reactions.

Table 5.6: **Effect of Watchlistings of the Bond Rating on Covered-Bond Prices.**
This table reports the numbers of events, average covered-bond program SARs and ARs around watchlistings and downgrades of bond ratings, and significance of the t-test, the signed-rank test, and the sign test. Statistical inference is based on SARs (left-hand side of a cell) and ARs (right-hand side of a cell), respectively. Results are presented separately for negative watchlistings (Panel A), downgrades with a prior negative watchlisting (Panel B), and downgrades without a prior negative watchlisting (Panel C), respectively. Results are further presented separately for different sub-periods of the event period. In Panel D, significance of t-tests of stronger effects around downgrades without a prior negative watchlisting than around downgrades with a prior negative watchlisting are presented. The symbols *, **, and *** indicate statistical significance at the 5%, 1%, and 0.1% level, respectively, and significance levels are based on one-sided tests.

		Watchlist negative					
		[-5,-1]		[0,1]		[2,5]	
Panel A:							
	Obs.	378		378		378	
	SAR	-0.1996		-0.3500		-0.6465	
Both Rating	AR	-0.08%		-0.10%		-0.01%	
Agencies	t-test	*	*	***	***	**	
	Sign rank			***	***	**	**
	Sign test			**	**	**	**
		Downgrades with watchlisting					
Panel B:							
	Obs.	259		259		259	
	SAR	-0.0929		-0.2442		-0.1553	
Both Rating	AR	0.04%		-0.05%		-0.12%	
Agencies	t-test			**			**
	Sign rank			*	*		
	Sign test						
		Downgrades without watchlisting					
Panel C:							
	Obs.	111		111		111	
	SAR	-0.2795		-0.2223		-1.5769	
Both Rating	AR	0.00%		0.04%		-0.75%	
Agencies	t-test					***	***
	Sign rank					***	***
	Sign test					***	***
Panel D:	Stronger effect for unexpected downgrades?						
t-test						***	***

In addition to investigating the statistical significance, it is interesting to investigate the economic significance by examining the absolute values of the SARs and ARs. For example, the effect of downgrades without a previous watchlisting appears to be far more intense in the $[2, 5]$-period. To obtain evidence on whether the difference is statistically significant, we compare the SARs and ARs in each sub-period for both types of downgrades by using one-sided t-tests. The corresponding results are shown in Panel D. It can be seen that both SARs and ARs are significantly different in the last sub-period but not in the first two sub-periods. Therefore, we have shown that the effect of unexpected downgrades is indeed higher than that of expected downgrades, at least in the sub-period following downgrades. The result of no stronger effect around unexpected downgrades in the period immediately around a downgrade is in line with the results obtained by May (2010), who finds no significant effect of a prior watchlisting on the intensity of abnormal price reactions following downgrades of corporate bonds. Unfortunately, however, he investigates this difference only in the $[0, 1]$-period, so we cannot compare the results in the other sub-periods.

Finally, we examine whether there occur abnormal price reactions around events regarding issuer ratings. The results are presented in Table 5.7. In Panel A, the results for upgrades and downgrades of issuer ratings are shown. In contrast to upgrades of bond ratings, for upgrades of issuer ratings, significant SARs/ARs can be verified in the $[2, 5]$-period. For downgrades, the SARs and ARs are negative and significant, showing that, regardless of changes of the bond rating, changes of the issuer rating indeed affect covered-bond prices. This result is in contrast to our expectation of no effect of issuer-rating events on covered-bond prices. Thus, investors do not rely solely on the cover pool but directly take the financial situation of the issuer into account as well.

In Panel B, the results regarding watchlistings of issuer ratings are shown.[160] For positive watchlistings, there are significant anticipation effects in the $[-5, -1]$-period. In the $[0, 1]$- and the $[2, 5]$-period, however, SARs and ARs are not significant. For negative watchlistings, analogous to negative watchlistings of bond ratings, significant negative

[160] Since there are 24 positive watchlistings of issuer ratings in our dataset, in contrast to bond ratings, we can investigate the effect of positive watchlistings of issuer ratings.

Table 5.7: **Effect of Issuer-Rating Events on Covered-Bond Prices.**
This table reports the numbers of events, average covered-bond program SARs and ARs around issuer-rating events, and significance of the t-test, the signed-rank test, and the sign test. Statistical inference is based on SARs (left-hand side of a cell) and ARs (right-hand side of a cell), respectively. Results are presented separately for downgrades and upgrades of issuer ratings (Panel A), and negative and positive watchlistings of issuer ratings (Panel B). Results are further presented separately for different sub-periods of the event period. The symbols *, **, and *** indicate statistical significance at the 5%, 1%, and 0.1% level, respectively, and significance levels are based on one-sided tests.

		Downgrades						Upgrades					
		[-5,-1]		[0,1]		[2,5]		[-5,-1]		[0,1]		[2,5]	
Panel A:													
	Obs.	312		312		312		91		91		91	
	SAR	-0.5600		-0.5872		-1.2757		0.2094		-0.3180		0.3891	
All Rating	AR	-0.05%		-0.08%		-0.11%		0.03%		-0.01%		0.04%	
Agencies	t-test	***		**	**	***	***						*
	Sign rank	*				***	**					*	*
	Sign test	*	*			*	**					*	*

		Watchlist negative						Watchlist positive					
Panel B:													
	Obs.	143		143		143		24		24		24	
	SAR	-0.8484		-0.4531		-0.7534		1.0639		0.3123		-0.3223	
All Rating	AR	-0.06%		-0.01%		-0.06%		0.08%		0.04%		0.00%	
Agencies	t-test	*						*	**		*		
	Sign rank					*		**	**				
	Sign test			*		**		*	*				

abnormal price reactions in the $[2,5]$-period can be observed. Thus, investors indeed react to negative issuer-rating events, and there is even evidence for positive abnormal price reactions after upgrades. Furthermore, there are also positive abnormal price reactions directly before positive watchlistings. A possible explanation of such positive effects might be that news about the issuer itself is more often conveyed to the public than news about covered bonds. Such news about the issuer might lead to positive events regarding the issuer rating and positive immediate price reactions of covered bonds. Overall, we can conclude that in addition to bond ratings, investors indeed consider issuer ratings in their investment decisions.

5.5.2 Cross-Sectional Analysis of Abnormal Price Reactions

In the previous subsection, we have shown that abnormal price reactions are far more distinct around negative events than around positive rating events. Therefore, we want to investigate what factors influence the magnitude of the abnormal price reaction after downgrades in this subsection. For this purpose, we separately examine abnormal price reactions around downgrades of the two rating types in more detail by performing cross-sectional OLS regressions with SARs/ARs in the $[0, 1]$-period as dependent variables. Because we were not able to verify significant abnormal price reactions immediately after upgrades in the previous subsection, we do not investigate influencing factors of SARs/ARs after upgrades in more detail. Before presenting the results on effects of downgrades, we discuss possible influencing factors and describe the explanatory variables used in the analyses.

As we mentioned in Section 5.2, a significant abnormal price reaction is expected if a rating event brings new information to the market. If there are ratings by more than one credit rating agency, a rating change by one rating agency might be considered new information by market participants only if the new rating is worse than other existing ratings in the case of a downgrade or if it is better in the case of an upgrade. Furthermore, if more than one rating exists, many investors might use the lower rating to determine the split rating of the covered bond. Thus, a downgrade leading to a new minimum rating often also leads to a lower split rating, which can be important for internal or external guidelines regarding minimum (split) ratings that investors must consider.[161] To investigate whether such rating events lead to stronger price reactions, we construct the dummy variable *Minimum Rating*, which equals one if the downgraded rating of the covered-bond program/the issuer is the new minimum rating after the downgrade.

In Table 5.6, we examined differences in the reactions after unexpected downgrades (i.e., downgrades without a prior negative watchlisting) compared with expected downgrades (i.e., downgrades with a prior negative watchlisting). To also investigate differences

[161] If a covered bond is rated by only one credit rating agency, a downgrade automatically leads to a new minimum rating.

between effects around downgrades with and without a prior negative watchlisting in the cross-sectional analysis, we construct the dummy variable *Expected Downgrade*, which equals one if there is a negative watchlisting prior to the downgrade.

As described in Section 2.3, the border between an investment-grade rating and a speculative-grade rating is especially important from a regulatory viewpoint because banks and insurance companies, which form a large group of covered-bond investors,[162] have to fulfill stricter requirements concerning their reserve capital for bonds with a speculative-grade rating. For example, as shown in Section 2.3.1, the risk weighting under Basel III/the CRR for banks in the European Union is lower for covered bonds than for senior unsecured bonds but it nevertheless increases from 20% for covered bonds with a rating of A or BBB to 50% for covered bonds with a BB-rating, indicating the importance of the border between investment and speculative grade. For corporate bonds, for example, Bongaerts et al. (2012) empirically show that there are significantly different price reactions following rating changes concerning the classification as investment grade or speculative grade. To account for this fact, several studies investigating the effects of rating events on security prices split their datasets into subsamples; one for investment-grade rating events and one for speculative-grade rating events,[163] and generally, the effects of rating events have shown to be more pronounced for speculative-grade ratings. Since, due to the dual recourse of investors, covered bonds tend to have better ratings than unsecured corporate bonds, although the average rating has decreased after the financial crisis and the subsequent sovereign debt crisis,[164] the number of events within the speculative-grade area is quite low. However, the downgrade of a covered bond from investment grade to speculative grade might have a considerably stronger impact than other downgrades since more investors might be constrained to sell the security owing to regulatory issues, internal guidelines concerning minimum ratings, or reputational reasons because investors might not want speculative-grade investments in their portfolio. Therefore, we construct the dummy variable *IG/SG Border*, which equals one if the rating migrated from investment grade to speculative grade.

[162]See Caris (2014).
[163]See e.g., Hand et al. (1992); Cantor and Packer (1996); May (2010).
[164]See Melms and Schulz (2013).

In footnotes 22 and 32 as well as when we described our dataset in Section 5.4, we have already addressed so-called multi-issuer Cédulas, which are securities in which several issuers combine their covered-bond issuances. As events regarding this covered-bond type account for more than half of the dataset of bond rating downgrades, we construct the dummy variable *Multi-Issuer Cédulas*, which equals one if the covered bond is a multi-issuer Cédula, to investigate whether abnormal price reactions are different for such covered bonds.

We further aim to test whether the effect of a downgrade is more distinct if the downgrade is stronger. Therefore, we include the variable *Rating Difference*, which contains the number of notches that the rating was downgraded. We also include a dummy variable for downgrades by S&P (*S&P*), since we have seen differences between the two rating agencies in Table 5.5. Additionally, we include a dummy variable for covered-bond programs backed by public loans (*Public CB*), since there might be differences in the abnormal price reaction between downgrades of different covered-bond types because we also showed slight differences in the factors influencing risk premiums of the two covered-bond types in Chapter 4. Further, we include a dummy variable for covered-bond programs issued in Spain (*Spain*) because Spanish observations account for the majority of the dataset regarding bond-rating downgrades, as described in Section 5.4.2.

Finally, we construct dummies for the different rating classes used to compute the benchmark returns described in Section 5.3 as controls. For downgrades of issuer ratings, we use rating classes of the issuer rating constructed similar to those of the bond rating. The results of the analyses are shown in Table 5.8.

Table 5.8: **Cross-Sectional Investigation of SARs/ARs around Downgrades.** This table reports results of cross-sectional OLS regressions. The dependent variable is SAR (columns (1) and (3)) or AR (columns (2) and (4)) in the period $[0, 1]$ around a downgrade at day $t = 0$. In columns (1) and (2), downgrades of bond ratings are investigated. In columns (3) and (4), downgrades of issuer ratings are investigated. *Minimum Rating* is a dummy variable equal to one if the downgraded rating is lower than all other ratings of the covered-bond program/the issuer after the downgrade. *Expected Downgrade* is a dummy variable equal to one if there was a negative watchlisting prior to the downgrade. *IG/SG Border* is a dummy variable equal to one if the rating migrated from investment grade to speculative grade. *Multi-Issuer Cédulas* is a dummy variable equal to one if the covered bond is a multi-issuer Cédula. *Rating Difference* is the number of notches the rating was downgraded. *S&P* is a dummy variable equal to one if the downgrade was conducted by S&P. *Public CB* is a dummy variable equal to one if the covered-bond program is backed by public loans. *Spain* is a dummy variable equal to one if the covered-bond program is issued in Spain. Standard errors shown in parentheses are Huber/White standard errors and are therefore robust to heteroscedasticity. The symbols †, *, **, and *** indicate statistical significance at the 10%, 5%, 1%, and 0.1% level, respectively.

	(1) Bond Rating SAR	(2) Bond Rating AR	(3) Issuer Rating SAR	(4) Issuer Rating AR
Minimum Rating	-0.239	-0.111	-0.172	-0.0347
	(0.193)	(0.0744)	(0.444)	(0.0824)
Expected Downgrade	0.152	-0.0274	1.111**	0.136†
	(0.188)	(0.0751)	(0.409)	(0.0720)
IG/SG Border	-1.436**	-0.413*	-0.0494	-0.0105
	(0.474)	(0.164)	(0.508)	(0.121)
Multi-Issuer Cédulas	0.0701	0.116		
	(0.220)	(0.0888)		
Rating Difference	-0.191***	-0.0656**	-0.846*	-0.207*
	(0.0551)	(0.0231)	(0.417)	(0.0957)
S&P	-0.256	-0.153*	-0.254	-0.0443
	(0.162)	(0.0657)	(0.445)	(0.0696)
Public CB	-0.663*	-0.0268	-0.222	0.0156
	(0.308)	(0.0554)	(0.509)	(0.0762)
Spain	-0.230	-0.00342	1.259***	0.194**
	(0.221)	(0.0818)	(0.340)	(0.0623)
Constant	1.104**	0.491***	5.024*	1.066*
	(0.363)	(0.135)	(2.293)	(0.502)
Rating Class FE	Yes	Yes	Yes	Yes
Observations	370	370	312	312
R^2	0.135	0.104	0.064	0.060

In columns (1) and (2), we investigate downgrades of the bond rating, whereas in columns (3) and (4), we investigate downgrades of the issuer rating. The dependent variable in columns (1) and (3) is SAR (in units of standard deviation) in the $[0, 1]$-period, and in columns (2) and (4), it is AR (in percentage points) in this period. The results are similar for SARs and ARs with respect to the same rating type, but they differ between the two rating types. Regarding bond ratings, abnormal price reactions are significantly stronger if the rating migrates from investment grade to speculative grade, indicating the importance of the border between these rating areas. With an effect of -1.4 for SARs and -0.41% for ARs, respectively, compared to average SARs and ARs of -0.24 and -0.03%, respectively, for all downgrades (as shown in Panel A of Table 5.5), the effect is economically highly relevant. We find no significantly different abnormal price reactions for a new minimum rating, expected downgrades, or downgrades concerning multi-issuer Cédulas. However, we can verify a connection between the strength of the abnormal price reaction and the number of notches that the rating is downgraded, as shown by the negative and significant coefficient of *Rating Difference* for both SARs and ARs. Investigating differences between downgrades by the two rating agencies, we find a negative and significant coefficient of the dummy variable describing a downgrade conducted by S&P at least for ARs, indicating that downgrades by S&P have a stronger immediate effect on covered-bond prices. This result is in line with the results concerning downgrades shown in Table 5.5. Finally, we find a significant and negative coefficient for *Public CB*, indicating a stronger effect of downgrades for public covered bonds than for mortgage covered bonds, but we cannot verify significantly different abnormal price reactions around downgrades of covered bonds issued in Spain.

Regarding issuer ratings, only some results are similar to those obtained for downgrades of bond ratings. In line with the results regarding bond ratings, there is no statistically significant effect of *Minimum Rating*, but in contrast to the results for bond ratings, we can verify significantly less intense abnormal price reactions for expected downgrades of issuer ratings and no stronger effect of downgrades from investment grade to speculative grade. We again find a significantly negative relationship between the number of notches that the rating is downgraded and the (standardized) abnormal return. In addition, this effect is more pronounced for issuer-rating events than for bond-rating events. Each additional notch that the rating is downgraded decreases the SAR/AR by -0.85/-0.21% compared with -0.19/-0.07% in columns (1) and (2). No differences regarding the intensity of abnormal price reactions between the two different rating agencies or between the two different covered-bond types can be verified. However, the coefficient of the dummy variable for downgrades of Spanish covered bonds is positive and significant. Apparently, investors react less negatively to downgrades regarding the issuer rating than to downgrades regarding the bond rating for covered bonds issued in Spain. A possible reason for this result might be the so-called sovereign ceiling.[165] As the rating of Spain was downgraded several times during the time period covered by our dataset, ratings of Spanish financial institutions have been downgraded as well, and covered-bond investors may have reacted less intensely to such downgrades.

Overall, for both rating types, the abnormal price reaction is more intense when the rating has been downgraded by more notches. The strongest effects regarding downgrades of the bond rating can be observed if the rating migrates from investment to speculative grade and there is slight evidence of stronger effects of downgrades conducted by S&P and of downgrades of public covered bonds. Regarding issuer ratings, the number of notches that the rating is downgraded is also crucial, but neither the border between investment grade and speculative grade nor the credit rating agency conducting the downgrade of the type of covered bond is relevant for the intensity of the abnormal price reaction. Instead, the abnormal price reaction is significantly less intense for expected downgrades or for covered bonds issued in Spain. A possible explanation for the differing results concerning the border between investment and speculative grade might be that (internal or external) guidelines focus on bond ratings. A downgrade of the bond rating to speculative grade results in higher capital requirements for banks and insurance companies, whereas this causality does not hold for downgrades of the issuer rating. This finding is supported by the effects of the rating class. None of the corresponding dummy variables is significant for SARs around bond-rating downgrades, and even the joint hypothesis of no effect of all these dummies together cannot be rejected by an F-test. This result indicates that the rating class is not per se important with respect to the intensity of the abnormal price reaction; rather, whether the new rating is relevant with regard to internal or external

[165] Sovereign ceiling or country ceiling describes the restriction that ratings of firms/securities are generally capped by the sovereign rating. According to Dierick (2016), both rating agencies use this restriction in their covered-bond ratings. Reasons for a sovereign ceiling are discussed in Borensztein et al. (2013), for example.

regulations is important. Regarding issuer ratings, however, the rating class dummies are jointly significant, indicating that regarding this rating type, differences between the abnormal price reactions around downgrades in different rating classes do exist.

5.5.3 Robustness Checks

We also want to investigate whether the results obtained in the previous subsection regarding bond ratings can be verified by separately conducting event studies for different subsamples of the dataset. As we have investigated only the $[0,1]$-period in the cross-sectional analysis, we can thereby examine whether the effects also hold in the other sub-periods.

First, we investigate whether abnormal price reactions are stronger if the downgraded rating is the new minimum rating or the upgraded rating is the new maximum rating, respectively. The corresponding results are shown in Table 5.9. As shown in Panel A, we find highly significant SARs around downgrades leading to a new minimum rating in the $[0,1]$- and the $[2,5]$-period and significant ARs in the $[2,5]$-period. For other downgrades, on the other hand, only ARs in the $[2,5]$-period are significantly negative, as shown in Panel B. Comparing the absolute values of SARs (and also ARs) for both types of downgrades for every sub-period using one-sided t-tests, as presented in Panel C, we can verify no significant differences, however. Regarding upgrades, significant effects can be verified for neither upgrades leading to new maximum ratings nor other upgrades.

Table 5.9: **Robustness Check: Effect of Min./Max.-Rating Events on Covered-Bond Prices.**
This table reports the numbers of events, average covered-bond program SARs and ARs around upgrades and downgrades of the bond rating, and significance of the t-test, the signed-rank test, and the sign test. Statistical inference is based on SARs (left-hand side of a cell) and ARs (right-hand side of a cell), respectively. Results are presented separately for downgrades leading to a new minimum rating and upgrades leading to a new maximum rating (Panel A) and other downgrades and upgrades (Panel B), respectively. Results are further presented separately for different sub-periods of the event period. In Panel C, significance of t-tests of stronger effects around min./max. rating changes than around other rating changes are presented. The symbols *, **, and *** indicate statistical significance at the 5%, 1%, and 0.1% level, respectively, and significance levels are based on one-sided tests.

		Downgrades			Upgrades		
		[-5,-1]	[0,1]	[2,5]	[-5,-1]	[0,1]	[2,5]
Panel A:							
	Obs.	298	298	298	44	44	44
	SAR	-0.1293	-0.2697	-0.5720	-0.3886	-0.1577	-0.0503
Min./Max.	AR	0.01%	-0.05%	-0.27%	-0.12%	-0.01%	0.04%
Rating	t-test		**	*** ***			
	Sign rank		*	** **			
	Sign test			* *			
Panel B:							
	Obs.	72	72	72	13	13	13
	SAR	-0.2299	-0.1046	-0.6223	-0.2665	-0.3167	-0.4726
Other	AR	0.10%	0.07%	-0.47%	-0.04%	0.01%	-0.08%
Ratings	t-test			* **			
	Sign rank			**			
	Sign test			*			
Panel C:	Stronger effects for min./max. rating changes?						
	t-test						

Next, we examine the border between investment and speculative grade. The results are presented in Table 5.10. In Panel A, effects of downgrades from investment to speculative grade are presented, Panel B presents effects of other downgrades. The results show that SARs and ARs are considerably smaller (i.e., the effects are considerably stronger) for IG/SG downgrades in all three sub-periods compared to the respective values for other downgrades.[166] The differences are most intense in the $[0, 1]$- and the $[2, 5]$-period. With values for the SARs of -2.03 and -2.54 around IG/SG downgrades in comparison with

[166] With only 17 observations, the subsample of downgrades from investment grade to speculative grade is quite small. However, the sample size is sufficient to test for significance.

Table 5.10: **Robustness Check: Effect of Bond-Rating Events around the IG/SG Border on Covered-Bond Prices.**
This table reports the numbers of events, average covered-bond program SARs and ARs around downgrades of the bond rating, and significance of the t-test, the signed-rank test, and the sign test. Statistical inference is based on SARs (left-hand side of a cell) and ARs (right-hand side of a cell), respectively. Results are presented separately for downgrades from investment grade to speculative grade (Panel A) and other downgrades (Panel B), respectively. Results are further presented separately for different sub-periods of the event period. In Panel C, significance of t-tests of stronger effects around downgrades from investment grade to speculative grade than around other downgrades are presented. The symbols *, **, and *** indicate statistical significance at the 5%, 1%, and 0.1% level, respectively, and significance levels are based on one-sided tests.

		Downgrades					
		[-5,-1]		[0,1]		[2,5]	
Panel A:							
	Obs.	17		17		17	
	SAR	-0.5434		-2.0315		-2.5432	
IG/SG	AR	-0.22%		-0.58%		-0.67%	
	t-test	*		***	**	**	*
	Sign rank	*		***	**	***	**
	Sign test			**	**	***	***
Panel B:							
	Obs.	353		353		353	
	SAR	-0.1299		-0.1512		-0.4873	
Not IG/SG	AR	0.04%		0.00%		-0.29%	
	t-test			*		***	***
	Sign rank					*	***
	Sign test					*	**
Panel C:	Stronger effects?						
	t-test			***	***	***	

-0.15 and -0.49 around other downgrades, the absolute values are many times higher in these sub-periods. The same holds for the absolute values of ARs, though they are less pronounced (-0.58% and -0.67% vs. 0.00% and -0.29%, respectively). These insights are supported by again conducting a one-sided t-test of different SARs and ARs in the three sub-periods, as shown in Panel C. For the period prior to the event, significantly different abnormal price reactions cannot be verified, but for the other two sub-periods, SARs around IG/SG downgrades are smaller, and the difference is highly significant. The same also holds for ARs in the $[0, 1]$-period.

We also investigate possibly different effects for rating changes concerning multi-issuer Cédulas and other covered bonds. The corresponding results can be found in Table 5.11.

Table 5.11: **Robustness Check: Effect of Bond-Rating Events on Prices of Multi-Issuer Cédulas.**
This table reports the numbers of events, average covered-bond program SARs and ARs around upgrades and downgrades of bond ratings, and significance of the t-test, the signed-rank test, and the sign test. Statistical inference is based on SARs (left-hand side of a cell) and ARs (right-hand side of a cell), respectively. Results are presented separately for downgrades and upgrades of multi-issuer Cédulas (Panel A) and other downgrades and upgrades (Panel B), respectively. Results are further presented separately for different sub-periods of the event period. In Panel C, significance of t-tests of stronger effects around rating changes of multi-issuer Cédulas than around rating changes of other covered bonds are presented. The symbols *, **, and *** indicate statistical significance at the 5%, 1%, and 0.1% level, respectively, and significance levels are based on one-sided tests.

		Downgrades			Upgrades		
		[-5,-1]	[0,1]	[2,5]	[-5,-1]	[0,1]	[2,5]
Panel A:							
	Obs.	203	203	203	20	20	20
	SAR	-0.0108	-0.3945	-0.9767	-0.6284	-0.1579	0.2490
Multi-Issuer	AR	0.10%	-0.04%	-0.56%	-0.26%	0.00%	0.03%
Cédulas	t-test		***	*** ***			
	Sign rank		** *	*** ***			
	Sign test		* *	** ***			
Panel B:							
	Obs.	167	167	167	37	37	37
	SAR	-0.3167	-0.0469	-0.1016	-0.2160	-0.2134	-0.3605
Other	AR	-0.06%	-0.01%	-0.01%	-0.01%	-0.01%	0.01%
Covered Bonds	t-test	*					
	Sign rank						
	Sign test						
Panel C:	Stronger effects for multi-issuer Cédulas rating changes?						
	t-test		*	*** ***			

Panel A shows the effects for multi-issuer Cédulas and in Panel B, results of rating changes concerning other covered bonds are presented. SARs and ARs around upgrades are not statistically significant in any sub-period for both covered-bond types. Consequently, when conducting a one-sided t-test, we do not find evidence of a stronger effect of upgrades for multi-issuer Cédulas in any of the sub-periods, as shown in Panel C. Regarding downgrades, however, we find differences between the two subsamples. For multi-issuer Cédulas, the effects are highly significant in the $[0, 1]$- and the $[2, 5]$-period, whereas for other covered bonds, we do not find significantly negative abnormal price reactions in any of the three sub-periods. Furthermore, the absolute values of the SARs and ARs are higher for multi-issuer Cédulas in the last two sub-periods, indicating a stronger effect than for other covered bonds. This result can be partly verified by a one-sided t-test showing significantly stronger effects of downgrades for multi-issuer Cédulas in the last two sub-periods with regard to SARs and at least in the last sub-period with regard to ARs. However, as we have seen no effect of the multi-issuer Cédulas dummy variable in the cross-sectional regression, the stronger effect immediately following a downgrade cannot be verified when we control for other potential influencing factors.

Finally, we present a robustness check of the results regarding negative watchlistings obtained in Section 5.5.1. The rating methodologies of the credit rating agencies are refined regularly. On the day on which a new methodology is first applied, several covered-bond programs could be placed on watch, and the in-depth review occurs subsequently. According to Forster and Purwin (2014), S&P's methodology change effective on 16 December 2009 was one of the most severe changes in recent years. On the date of the adoption of the new methodology, S&P placed nearly all of their rated covered-bond programs on the watchlist.[167] The high number of negative watchlistings by S&P on this date explains the higher number of negative watchlistings than of downgrades by S&P in the entire dataset what differs from Fitch, as shown in Table 5.3. Since these purely methodology-induced watchlistings were undertaken for a large group of covered-bond programs, investors might have reacted differently to these watchlistings than to other watchlistings. Thus, we investigate the effect of these watchlistings separately. The results are shown in Table 5.12.

[167]See Naylor et al. (2009).

Table 5.12: **Robustness Check: Effect of Methodology-induced Watchlistings on Covered-Bond Prices.**
This table reports the numbers of events, average covered-bond program SARs and ARs around negative watchlistings of bond ratings, and significance of the t-test, the signed-rank test, and the sign test. Statistical inference is based on SARs (left-hand side of a cell) and ARs (right-hand side of a cell), respectively. Results are presented separately for negative watchlistings by S&P on 16 December 2009 (Panel A), other negative watchlistings by either Fitch or S&P (Panel B), and other negative watchlistings only by S&P (Panel C), respectively. Results are further presented separately for different subperiods of the event period. Furthermore, in Panels B and C, significance of t-tests of stronger effects around non-methodology-induced than around other negative watchlistings are presented. The symbols *, **, and *** indicate statistical significance at the 5%, 1%, and 0.1% level, respectively, and significance levels are based on one-sided tests.

		Watchlist negative 16 December 2009					
		[-5,-1]		[0,1]		[2,5]	
Panel A:							
	Obs.	53		53		53	
	SAR	0.9143		0.3113		1.3043	
S&P	AR	0.09%		0.03%		0.11%	
	t-test						
	Sign rank						
	Sign test						
		Watchlist negative not 16 December 2009					
Panel B:							
	Obs.	325		325		325	
	SAR	-0.3813		-0.4578		-0.9646	
All Rating	AR	-0.11%		-0.12%		-0.03%	
Agencies	t-test	***	**	***	***	***	
	Sign rank	**	*	***	***	***	***
	Sign test			***	***	***	***
		Stronger effects?					
	t-test	***	*	**	**	***	
		Watchlist negative not 16 December 2009					
Panel C:							
	Obs.	171		171		171	
	SAR	-0.3661		-0.5608		-1.2666	
S&P	AR	-0.16%		-0.17%		-0.23%	
	t-test	**	*	***	***	**	***
	Sign rank			***	***	***	***
	Sign test			**	***	***	***
		Stronger effects?					
	t-test	***	*	**	**	**	***

In our dataset, there were 53 negative watchlistings by S&P on 16 December 2009. Actually, there have been 96 negative watchlistings of covered-bond programs and two placements on the developing watchlist,[168] but owing to the illiquidity of the asset class, we can investigate the presented subset only. For these negative watchlistings, no negative effect can be verified in any of the sub-periods, as can be seen in Panel A. Results concerning other negative watchlistings conducted by either Fitch or S&P are shown in Panel B. The effects are consistent with our previous findings shown in Panel A of Table 5.6; we now even find evidence for negative abnormal price reactions in the $[-5,-1]$-period. A comparison of the SARs and ARs for the two subsets, again using a one-sided t-test, shows that the differences are indeed statistically significant in each sub-period for SARs and in the first two sub-periods for ARs. We further investigated SARs and ARs around other negative watchlistings conducted by S&P only, and we obtained similar results, as shown in Panel C. Therefore, we can state that market participants react differently to methodology-induced negative watchlistings than to others.[169]

[168] See Naylor et al. (2009).

[169] Four months after the implementation of the new methodology, S&P had reviewed 56 of the 98 watchlistings. The results were only four actual downgrades, one upgrade and 51 affirmations of the rating,[170] which supports the lack of a negative market reaction.

5.5.4 Discussion

Around downgrades of bond ratings, we have shown abnormal price reactions of approximately -0.03% and -0.31% in the $[0,1]$- and $[-5,5]$-event periods, respectively, and we have shown no abnormal price reactions around upgrades (cf. Table 5.5). Around downgrades of issuer ratings, abnormal price reactions amounted to -0.08% and -0.24% in the two periods, respectively. Regarding upgrades, only little abnormal price reactions can be verified (cf. Table 5.7). Comparing these results with those obtained by May (2010), who finds abnormal returns of -0.64% around downgrades and 0.21% around upgrades only in the $[0,1]$-period, the effect of rating changes is rather small for covered bonds compared with corporate bonds. However, as mentioned in Section 5.4.2, the average rating of covered bonds is considerably higher than that of corporate bonds. Restricting the subsample to cover only rating events with the pre-event rating being investment grade, May (2010) finds no significant effect around upgrades, and the effect around downgrades is less intense, with average abnormal returns of -0.45% in the $[0,1]$-period. Even in this subsample, however, the fraction of a pre-event rating of AAA or AA is only approximately 20% compared with almost 70% in our dataset, as mentioned in Section 5.4.2. Investigating only downgrades from investment grade to speculative grade, we find ARs of -0.58% in the $[0,1]$-period, which is still less intense than the -0.83% obtained by May (2010) in his subsample of speculative grade downgrades.

Because there are significant differences between abnormal returns with different rating or maturity classes even if the matching portfolio model is used, as shown by Ederington et al. (2015), it is difficult to compare the obtained results based on cumulative abnormal returns. To (at least partly) overcome this problem, we therefore conducted the event studies with regard to standardized abnormal returns, which should be better suited to being compared between bonds with different rating or maturity classes. Regarding the significance of the effects of rating events, we find little effects of standardization. However, for an interpretation of the intensity of the effects for covered bonds compared with, for example, corporate bonds, standardized returns should be appropriate. Unfortunately, to our knowledge, no study has thus far investigated the effects of rating events on corporate bond prices by using abnormal returns stadardized based on their daily standard deviation.[171]

5.6 Interim Results

Owing to the dependency of repayments to investors of both the financial situation of the issuer and the cover pool, covered bonds exhibit a unique combination of risk exposures,[172] making assessments of the quality of a covered bond difficult. Furthermore, the disclosure of detailed information about the composition of the cover pools covering such bonds is still insufficient in this asset class. Thus, conducting individual credit-risk assessments of covered bonds is challenging for market participants, and therefore, external ratings by credit rating agencies play a crucial role in this asset class. Accordingly, we examined the impact of credit ratings on the covered-bond market in this chapter. More specifically, we are the first to investigate the immediate effects of rating events (rating changes or watchlistings) on covered-bond prices by using state-of-the-art event study methods, as recommended by Bessembinder et al. (2009) and Ederington et al. (2015). One of the main contributions of our study is that, in addition to investigating rating events regarding bond ratings, we also consider rating events regarding issuer ratings in our analyses, which is not possible for other asset classes, such as (unsecured) corporate bonds, because the bond rating generally equals the issuer rating for such securities.

Overall, our results confirm findings of studies investigating the effects of rating events on other asset classes in the way that negative bond-rating events lead to significantly negative abnormal returns, whereas positive events have no effect. In particular, however, in addition to negative events regarding bond ratings, we show that negative events regarding issuer ratings also have a significant effect on covered-bond prices.

[171] Hundt et al. (2016) use standardized cumulative abnormal returns in their investigation of convertible bonds, but they standardize their cumulative abnormal returns using the standard deviations of the cumulative abnormal returns instead of standardizing daily abnormal returns by daily standard deviations and cumulating the standardized returns afterward. Thus, their standardized abnormal returns cannot be compared to ours.

[172] See Forster and Purwin (2014).

For downgrades of bond ratings, we find significantly negative abnormal returns around the event date. Regarding upgrades, however, no such effects can be verified. Thus, we can confirm asymmetric covered-bond price adjustments concerning rating changes. This finding is in line with the findings of studies investigating other asset classes. However, the magnitude of abnormal price reactions is smaller than that for corporate bonds. Concerning watchlistings, we again find evidence of significant price reactions after a negative event. We further show that expected downgrades (i.e., downgrades with a prior negative watchlisting) lead to significantly lower price reactions than unexpected downgrades (i.e., downgrades without a prior negative watchlisting) in the days after such an event.

In addition to bond-rating events, we also examined events regarding issuer ratings because the covered-bond rating involves an evaluation of the financial situation of the issuer. We find that in addition to the abnormal price reactions around events regarding bond ratings, downgrades and negative watchlistings of issuer ratings also lead to significant abnormal returns of covered bonds. We even find light evidence for positive abnormal price reactions after positive rating events, indicating that covered-bond investors also consider issuer ratings in their trading decisions.

We further conducted a cross-sectional analysis of influencing factors of abnormal price reactions around downgrades of bond ratings or issuer ratings. Regarding regulatory influences, we find evidence of considerably stronger effects of downgrades of bond ratings around the investment-grade/speculative-grade border. Moreover, we can verify a connection between the strength of the abnormal price reaction and the number of notches that a rating is downgraded. Regarding downgrades of issuer ratings, the number of notches that the rating is downgraded is important with respect to the intensity of the abnormal price reaction, and the abnormal price reaction is less intense if the downgrade was expected.

Our results are relevant for all types of market participants in the covered-bond market since they enhance the understanding of price movements. Issuers have an incentive to maintain a high quality of their cover pools in order to avoid downgrades of their covered-bond programs, which may lead to lower prices and thus higher yields (i.e., higher refinancing costs when issuing new covered bonds from these covered-bond programs). Investors can consider the obtained results in their scenario analyses regarding potential losses in market value resulting from negative rating events. This finding is particularly important for the European Central Bank, as it has allocated covered bonds with a total volume of more than €259 billion by 16 March 2018, purchased during three different covered bond purchase programs,[173] although it plans to hold these investments until maturity.

[173] See https://www.ecb.europa.eu/mopo/implement/omo/html/index.en.html (Accessed: 21 March 2018).

5.7 Appendix

5.7.1 Event Study

Event studies can be used to measure the effect of a specific event on the the price of a security. If the market is efficient in the semi-strong form according to Fama (1970), market participants immediately employ the event in their trading decisions, leading to asset prices immediately reflecting a potential effect of the event. Thus, in an event study, the asset price is investigated shortly before and shortly after the event, and the true asset return in this (short) time period (called the event period) is then compared to the expected asset return in the event period to examine the event's effect on the asset price.[174]

With regard to the application of event studies on bond markets, several peculiarities have to be considered, such as multiple bonds per issuer or illiquidity of bond price data. Bessembinder et al. (2009), Ederington et al. (2015), and Maul and Schiereck (2017) explicitly investigate these issues and we incorporate their recommendations in our analyses. Independent of whether stocks or bonds are investigated, however, according to Campbell et al. (1997), seven steps have to be performed to conduct an event study. In the following, we list these seven steps and shortly describe how we perform them in the event study conducted in this chapter.

1. Event definition and choice of the event period.

   We define every rating change or watchlisting of a covered bond to be an event of interest and we set the event period to the eleven-day period $[-5, 5]$, as described in Section 5.3.

2. Choice of examined firms/securities.

   We examine all euro-denominated covered bonds with price observations between 2006 and 2014, as described in Section 5.4.

[174] See (Campbell et al., 1997, pp. 149ff.).

3. Choice of model for abnormal return calculation.

   We use the matching protfolio model as recommended by Bessembinder et al. (2009) and Ederington et al. (2015) to compute abnormal returns, as described in Section 5.3.

4. Choice of the estimation period.

   We use the 100-day estimation period $t = -105$ to $t = -6$ to estimate the standard deviations for the standardization of the abnormal returns, as described in Section 5.3.

5. Choice of statistical tests.

   We employ the parametric t-test and the non-parametric signed-rank test and sign-test, as described in Section 5.3. The tests are further described in the following section in this appendix.

6. Presentation of empirical results.

   We present the results of the empirical analyses in Section 5.5.

7. Interpretation and conclusions.

   We interprete the results when presenting them in Section 5.5 and we conclude in Section 5.6.

5.7.2 Statistical Tests

5.7.2.1 (One-sample) t-Test

Let $X_1, \ldots, X_n$ be independent and identically distributed (iid) random variables following a normal distribution with unknown expected value μ and standard deviation σ. We want to test whether μ is equal to a certain value $\mu*$, i.e., we test $H_0 : \mu = \mu*$ against $H_1 : \mu \neq \mu*$. Therefore, we use the following test statistic

$$T_{t-test} = \frac{\bar{X} - \mu*}{s/\sqrt{n}}, \tag{5.6}$$

with $\bar{X}$ and s being the estimators of μ and σ of the form

$$\bar{X} = \frac{1}{n}\sum_{i=1}^{n} X_i \quad \text{and} \quad s^2 = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(X_i - \bar{X})^2}. \tag{5.7}$$

Then, under the hypothesis, the test statistic T_{t-test} follows the Student-t-distribution with $n-1$ degrees of freedom.[175] To decide whether we reject the hypothesis, observations $x_1, \dots, x_n$ of the $X_1, \dots, X_n$ are used to compute 5.7 and the resulting value of 5.6 can be compared to critical values of the Student-t-distribution with $n-1$ degrees of freedom. Since in our setting, we want to know whether the mean of the (standardized) abnormal returns is different from zero, we set $\mu* = 0$. Furthermore, as mentioned in Section 5.3, we do not test $H_0 : \mu = 0$ against $H_1 : \mu \neq 0$, but we apply the one-sided t-test with null hypothesis that the mean (standardized) abnormal return is greater than or equal to zero (i.e., $H_0 : \mu \geq 0$ against $H_1 : \mu < 0$) for negative events and less than or equal to zero (i.e., $H_0 : \mu \leq 0$ against $H_1 : \mu > 0$) for positive events. The procedure is the same as described above; only the the critical values are different.

5.7.2.2 (Wilcoxon) Signed-Rank Test

In contrast to the one-sample t-test, which can be used to test whether independent normally distributed random variables' mean is zero, the (Wilcoxon[176]) signed-rank test tests whether the random variables' median is zero. It can also be tested whether the median is an arbitrary number a but this is the same as testing whether the difference between the iid random variables and a has a median of zero and therefore, we only consider the case where we test for zero median. In contrast to the t-test, we do not

[175] See Nikulin (2011).
[176] The test was first proposed by Wilcoxon (1945).

have to assume normality of the random variables. The only assumption of the test is that the distribution of the random variables is symmetric. Let again $x_1, \ldots, x_n$ be the observations from iid random variables $X_1, \ldots, X_n$. The absolute values $|x_i|, i = 1, \ldots, n$, of the observations are ranked[177] and then we construct the following:

$$r_i = sign(x_i) \cdot rank(|x_i|), \quad i = 1, \ldots, n. \tag{5.8}$$

Using these signed ranks, the test statistic can be computed as follows:

$$T_{signed-rank} = \sum_{i=1}^{n} r_i. \tag{5.9}$$

This test statistic follows a distribution with

$$E(T_{signed-rank}) = 0 \quad \text{and} \quad Var(T_{signed-rank}) = \sum_{i=1}^{n} r_i^2. \tag{5.10}$$

With these values, the z-score can be calculated as

$$z = \frac{T_{signed-rank}}{\sqrt{Var(T_{signed-rank})}} \tag{5.11}$$

and then be compared to critical values of the standard normal distribution.[178]

An alternative way of defining the test statistic is to only consider the positive ranks and compute the following test statistic:

$$T_{signed-rank,+} = \sum_{i=1}^{n} 1_{[sign(x_i)=+]} \cdot rank(|x_i|), \tag{5.12}$$

where $1_{[\cdot]}$ is the indicator function. This test statistic follows a distribution with

$$E(T_{signed-rank,+}) = \frac{n \cdot (n+1)}{4} \tag{5.13}$$

[177] If two or more observations are equal (in absolute terms), they are assigned the average rank.
[178] See StataCorpLP (2013a, pp. 2153f.).

and

$$Var(T_{signed-rank,+}) = \frac{1}{4}\sum_{i=1}^{n} r_i^2 = \frac{n \cdot (n+1) \cdot (2n+1)}{24}. \tag{5.14}$$

Again, these values can be used to compute the z-score[179]

$$z = \frac{T_{signed-rank,+} - E(T_{signed-rank,+})}{\sqrt{Var(T_{signed-rank,+})}} \tag{5.15}$$

and the resulting value can be compared to critical values of the standard normal distribution.[180]

5.7.2.3 Sign Test

Analogous to the signed-rank test, the sign test likewise tests whether iid random variables' median is zero. However, no additional assumptions such as a symmetric distribution have to be made. Let again $x_1, \ldots, x_n$ be the observations from iid random variables $X_1, \ldots, X_n$. The test statistic is the number n_+ of positive observations

$$n_+ = \sum_{i=1}^{n} 1_{[x_i>0]}. \tag{5.16}$$

Under the assumption that the probability of an observation to be zero is zero, the probability of an observation to be greater than zero is 1/2 and so is the probability of an observation to be less than zero, because under the null hypothesis, the median of the random variable is zero. Thus, the test statistic is binomially distributed with parameters n equal to the number of observations and $p = 1/2$, i.e.,

$$n_+ \sim binomial(n, 1/2). \tag{5.17}$$

[179] If there are observations with $x_i = 0$ or $x_i = x_j$, $i \neq j$, the variance has to be adjusted slightly.
[180] See StataCorpLP (2013a, pp. 2154f.).

If there is a number n_0 of observations equal to zero, than n_+ is binomially distributed with parameters $n - n_0$ and $p = 1/2$, i.e.,[181]

$$n_+ \sim binomial(n - n_0, 1/2). \tag{5.18}$$

To test for significance, either the probability of obtaining at least n_+ positive observations under the binomial distribution can be computed or a z-score can be calculated and compared to critical values from the standard normal distribution.

[181] See StataCorpLP (2013a, p. 2155.).

6 Conclusion

The beginning of this thesis pointed out that covered bonds were often considered almost default-risk-free due to the dual recourse investors have against both the cover pool and the issuer, but that this notion is likely to have changed. The reasons for this likely change are distortions in the financial markets affecting the international banking world, declining housing prices in several countries, and the awareness that even government bonds might contain substantial default risk. Against this background, the main focus of this thesis was on the risk assessment of covered bonds in the international secondary market.

Chapter 2 explained the fundamentals of covered bonds. Besides defining specific criteria, a bond must fulfill to qualify as a covered bond, it showed that while the outstanding volume of the entire covered-bond market, and particularly of mortgage covered bonds, increased in the recent decade, the outstanding volume of public covered bonds decreased steadily. This decrease was mainly driven by the German Pfandbrief market; in several other countries, the outstanding volume of public covered bonds actually increased. Furthermore, the chapter discussed differences compared to ABS/MBS. The main difference is that the cover assets remain on the issuer's balance sheet in the case of covered bonds, whereas in the case of ABS/MBS, the pool of assets is transferred via a 'true sale' to an SPV. Moreover, it showed that the rating methodologies of the three major CRAs all have the financial strength of the issuer as a starting point, leading to a generally higher covered-bond rating than the issuer rating. Finally, it was shown that covered bonds enjoy a preferential treatment under both the Basel III and the Solvency II regulations.

Despite their decreasing outstanding volume, public covered bonds are one of the most important refinancing instruments for banks that provide loans to local and regional governments in European countries. Against this background, in Chapter 3, factors influencing the risk premiums of public covered bonds in the international secondary market were investigated using a broad dataset with more than 70,000 weekly observations of 560 public covered bonds issued in ten countries and eight currencies. Using random effects and fixed effects estimations, the results showed that besides bond-specific factors, macroeconomic variables as well as exogenous events such as the financial crisis, the sovereign debt crisis, and the ECB's first covered bond purchase program affect risk premiums of public covered bonds. The start and end dates of the two economic crises were determined using threshold regression methods for panel data and an increasing effect was verified for both crises. The first purchase program, on the other hand, led to lower risk premiums. Concerning the macroeconomic factors, the results verified a significantly negative effect of the development of real estate prices in a country, among others. This seems surprising because only public covered bonds were investigated, and this variable has been seen as a proxy for the cover-pool quality in prior studies investigating only mortgage covered bonds. However, due to its function as a factor describing the macroeconomic environment and as an indicator of the quality of the issuers' balance sheets, it also affects risk premiums of public covered bonds. Moreover, the results showed significant differences in the effects for public covered bonds issued in different countries. In particular, the results for the German Pfandbrief market differ significantly from those for bonds issued in other countries, and these differences can at least partly be explained by the characteristic of German BUNDs seen as safe-haven investments.

The objective of Chapter 4 was to investigate factors influencing risk premiums of mortgage covered bonds and to examine differences in the influencing factors of risk premiums between public and mortgage covered bonds. Using a dataset with more than 177,000 weekly observations from 1,267 mortgage covered bonds issued in more than 20 countries and ten currencies, it was shown that the results obtained in the literature for euro-denominated mortgage covered bonds in a few European countries can be transferred to a much broader transnational setting. Moreover, it was shown that most factors shown to influence risk premiums of public covered bonds in Chapter 3 also affect risk premiums of mortgage covered bonds. Noticeably, an increase in the government debt-to-GDP ratio in a country was shown to lead to an increase in the risk premiums of mortgage covered bonds issued in this country, which seems surprising since this variable was used as a proxy for the cover-pool quality of public covered bonds in Chapter 3. However, due to its function as a macroeconomic indicator, it also affects risk premiums of mortgage covered bonds. Finally, risk premiums of public and mortgage covered bonds were investigated together in Chapter 4. Using the combined dataset of public and mortgage covered bonds, it was shown that the negative effect of real estate prices was stronger for mortgage covered bonds and that the positive effect of the government debt-to-GDP ratio was stronger for public covered bonds. Thus, these variables can at least partly be seen as a proxy for the quality of the cover pools of the two covered-bond types.

The government-debt-to-GDP ratio and the development of real estate prices had to be used as proxies for the cover-pool quality due to often insufficient transparency concerning the composition of the cover pools. For the same reason, conducting appropriate credit-risk assessments of covered bonds is difficult, and therefore, external ratings by credit rating agencies play a crucial role in this asset class. Against this background, the effects of rating events on the prices of covered bonds were investigated in Chapter 5 using state-of-the-art event study methods recommended by Bessembinder et al. (2009) and Ederington et al. (2015). To compute the abnormal returns, the matching portfolio model was applied and bonds from the same covered-bond program were combined using the firm-level approach. Furthermore, to control for heteroscedasticity in the abnormal bond returns, the returns were standardized by dividing them by their empirical standard deviation. Since the bond rating depends on the issuer rating, as shown in Chapter 2, besides effects around bond rating events, effects around rating events regarding the issuer rating were also investigated. The dataset consisted of daily observations from more than 2,000 covered bonds and nearly 300 covered-bond programs. In general, the results showed that negative rating events (i.e., downgrades and negative watchlistings) regarding the bond rating and negative rating events regarding the issuer rating both have a significant effect on covered-bond prices. Positive rating events (i.e., upgrades and positive watchlistings), on the other hand, have no or only little effects on covered-bond prices. Furthermore, the results showed that the abnormal price reaction following a downgrade of the bond rating is stronger if the rating is downgraded from investment to speculative grade due to the regulatory importance of this boundary, or if the downgraded rating is the new minimum rating.

The results obtained in this thesis are relevant for all types of market participants. Knowing the factors influencing risk premiums of covered bonds is essential for issuing banks. Particularly during crisis periods with concomitant higher risk premiums than in non-crisis periods with generally lower risk premiums, they have an incentive to signal investors that their covered bonds exhibit a high quality to lower their refinancing costs. Since it was shown that proxies for the cover-pool quality affect risk premiums, a possible way of doing this is to regularly publish detailed data concerning the composition of the cover pool, giving investors the opportunity to conduct adequate assessments of a covered bond's quality. Particularly in the case of public covered bonds, knowing the factors influencing risk premiums is also important for public creditors, for example, local and regional governments, whose loans are combined in the cover pool because the issuing banks' refinancing costs also affect the local and regional governments' funding costs. Besides knowing the factors influencing the risk premiums of covered bonds, knowing the effects of negative rating events on covered-bond prices (and thus, on risk premiums of covered bonds) is also crucial for issuing banks. A negative rating event was shown to lead to lower covered-bond prices and hence, higher refinancing costs for future covered-bond issues. These higher refinancing costs due to the negative rating event can then be compared to the costs for maintaining or increasing the quality of the cover pool to maintain a specific rating to derive specific recommendations for action.

Besides issuing banks, covered-bond investors can use the results on the factors influencing risk premiums of covered bonds in the international secondary market in their investment decisions by being able to detect possibly anomalously priced covered bonds and to exploit such anomalies. Furthermore, if a market participant already holds a covered bond, the results can be used in the risk management processes. Similarly, knowledge of the effects of rating events on covered-bond prices can be used by covered-bond investors both in their investment decisions (e.g., by selling covered bonds they expect to be downgraded in the near future) and in their risk management processes (e.g., in scenario analyses of potential losses following a downgrade of one or more covered bonds in the investor's portfolio).

Several aspects in the context of covered-bond pricing were analyzed in this thesis. However, there are still further research questions that could be analyzed in the future. For example, Chapers 3 and 4 showed that proxies for the quality of a covered bond's cover pool significantly affect the covered bond's risk premium. Therefore, a detailed analysis of the effect of the cover-pool composition on covered bond risk premiums would be interesting. Prokopczuk et al. (2013) conduct such an analysis for the German Pfandbrief market because transparency concerning the cover-pool composition is exemplary in Germany due to restrictive legal requirements. In the international covered-bond market, however, transparency of the cover-pool composition is very heterogeneous and often not sufficient to conduct such analyses, as mentioned in Sections 2.2.1 and 3.2.2. However, since 2013, covered bonds can apply for the so-called 'Covered Bond Label' initiated by the European Covered Bond Council.[182] One of the Label's objectives is to improve cover pool transparency. It provides national transparency templates with defaults for desirable cover-pool information, which the issuers have to disclose regularly to obtain the Label. Using the cover-pool information accessible from the Label's website, the effect of the cover-pool composition on covered bond risk premiums should be investigable even for the international covered-bond market.

[182]See www.coveredbondlabel.com for more details.

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