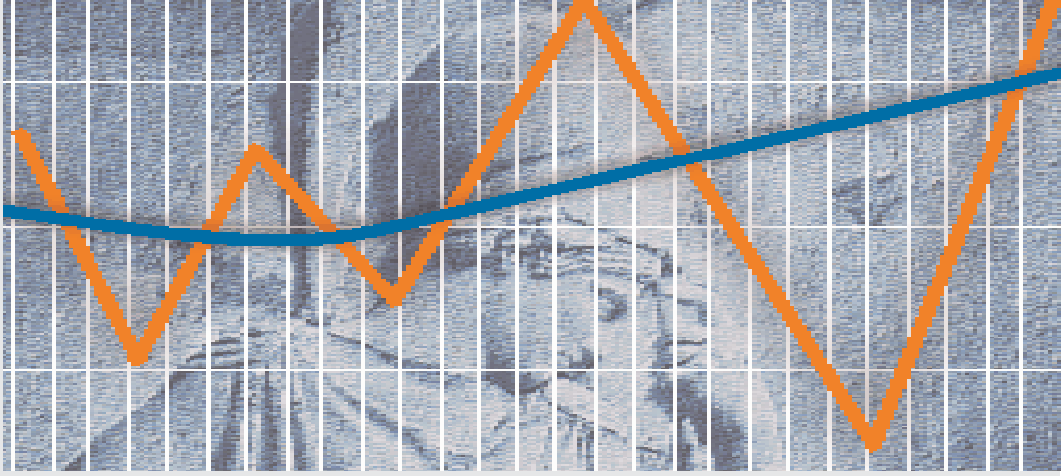

ifo Beiträge zur Wirtschaftsforschung

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The Collateral Framework of the Eurosystem and Its Fiscal Implications

Jakob Korbinian Eberl

ifo Institut

Leibniz-Institut für Wirtschaftsforschung

an der Universität München e.V.

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Schriftleitung: Chang Woon Nam

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Preface

This thesis was written by Jakob Eberl while having been a research assistant at the Center for Economic Studies (CES) at the University of Munich. It was completed in December 2015 and accepted as a doctoral thesis by the Department of Economics at the University of Munich in May 2016. The thesis tells the story of the Eurosystem's collateral framework and its fiscal implications in seven chapters (neglecting the introduction and the conclusion), which can be conceptually assigned to two parts.

The first part comprises Chapters 2 to 5 and elaborates on the Eurosystem's collateral framework. *Chapter 2* provides an introductory overview of the development of Eurosystem's monetary policy throughout the financial and sovereign debt crisis. It tracks the crisis mitigation of the Eurosystem and identifies collateral criteria as being crucial to this crisis mitigation, given that it facilitated increased liquidity provision. *Chapter 3* provides an in-depth analysis of the Eurosystem collateral framework. It compiles a comprehensive narrative database of general principles and amendments to the collateral framework. Moreover, the effects of amendments to the collateral framework on eligible marketable assets ("collateral pool") are elaborated along several dimensions. *Chapter 4* addresses the Eurosystem's risk control of collateral assets and how this was adjusted in response to factors that were exogenous and endogenous to the Eurosystem. Moreover, shortcomings of risk control are identified. *Chapter 5* sheds light on the effects of the Eurosystem's collateral framework as well as risk control by tracking the development of credit quality of collateral pledged with the Eurosystem. The model elaborated in this chapter argues that it is rationale for counterparties to pledge collateral of relatively low quality with the Eurosystem while relatively good collateral is pledged on the market ("adverse selection of collateral").

The fiscal implications of the collateral framework are investigated in the second part, which contains Chapters 6 to 8. *Chapter 6* formulates the framework for analyzing the fiscal implications, which is based on the analysis of fiscal sustainability. The common framework of fiscal sustainability under certainty is extended to uncertainty such that it facilitates deriving an intuitive indicator for assessing fiscal implications. *Chapter 7* elaborates on the fiscal implication of collateral criteria that evolves from the close link between collateral criteria, central bank finances and the government budget. It derives the optimal level of collateral criteria from a fiscal perspective and shows that uniform collateral criteria in a monetary union of heterogeneous countries give rise to cross-country fiscal implications. *Chapter 8* addresses the fiscal implication of collateral criteria that originates from the close link between collateral criteria and explicit government guarantees to the financial sector. It shows that the Eurosystem's collateral framework involves government discretion to free up collateral by giving explicit guarantees. This discretion is vital to government incentives to grant guarantees.

Finally, *Chapter 9* provides a summary and rethinks the Eurosystem's collateral framework based on the findings of the thesis.

JEL classification: E51, E52, E58, E62, E63, H12, H63, H77, H81.

Keywords: central banking, monetary policy, fiscal policy, Eurosystem, collateral, collateral framework, haircut, fiscal sustainability, central bank recapitalization, government guarantee.

Danksagung

Die vorliegende Arbeit entstand während meiner Tätigkeit als wissenschaftlicher Mitarbeiter am Center for Economic Studies und dem Lehrstuhl für Nationalökonomie und Finanzwissenschaft der Ludwig-Maximilians-Universität München. Sie wäre ohne die Unterstützung vieler Personen in meinem beruflichen und privaten Umfeld in dieser Form nicht zustande gekommen. Daher will ich nachfolgend denjenigen danken, die mich im Laufe meiner Promotion besonders unterstützt haben.

An erster Stelle möchte ich meinen Doktorvater Hans-Werner Sinn nennen. Für sein Vertrauen und seine Bereitschaft mir in meinen Forschungsinteressen freien Lauf zu lassen sowie für seine zahlreichen wertvollen Anregungen und Hilfestellungen möchte ich ihm herzlich danken. Sein Einfluss hat nicht nur diese Arbeit, sondern auch mein ökonomisches Verständnis nachhaltig geprägt. Darüber hinaus danke ich Clemens Fuest für seine Bereitschaft, die Rolle des Zweitgutachters zu übernehmen. Christoph Trebesch danke ich für die Unterstützung im Verlauf der vergangenen Jahre und seine Bereitschaft als mündlicher Prüfer zu fungieren. Teile dieser Arbeit entstanden während meines Forschungsaufenthalts als Visiting PhD Student am Massachusetts Institute of Technology. Unterstützt wurde ich dabei von Jim Poterba, wofür ihm mein besonderer Dank gilt.

In den vergangenen Jahren habe ich besonders von der Zusammenarbeit und dem intensiven Austausch mit Christopher Weber profitiert. Erkenntnisse dieser Zusammenarbeit finden sich in dieser Dissertation wieder. Christoph Winter danke ich insbesondere für seine zahlreichen Anmerkungen zur vorliegenden Arbeit. Danken möchte ich auch Darko Jus, mit dem ich in den ersten Jahren meiner Promotionszeit eng zusammen arbeiten durfte. Besonderer Dank für die gute Zusammenarbeit gilt zudem meinen (teils ehemaligen) Lehrstuhlkollegen Andreas Blöchl, Florian Buck, Susanne Wildgruber, Michael Stimmelmayr, Christian Beermann und Nadjeschda Arnold. Große Unterstützung auf administrativer Ebene erhielt ich von Ursula Baumann, Ulrike Gasser, Martina Grass, Renate Meitner und Susanne Wormslev.

Nicht zuletzt danke ich Sissi und meinen Eltern für ihre fortwährende und bedingungslose Unterstützung – dafür, dass ihr immer für mich da wart/seid.

München, im Dezember 2015

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Contents

List of Abbreviations/Acronyms

ABSs	Asset-Backed Securities
ABSPP	Asset-Backed Securities Purchase Programme
ACC	additional credit claim
ANFA	agreement on net-financial assets
AP	asset purchases
BSLI	balance sheet leanness indicator
CAP	cash provider
CBPP	Covered Bond Purchase Programme
CCP	central (clearing) counterparty
CDS	credit default swap
CE	certainty equivalent
CF	cash flow
CMBS	commercial mortgage-backed security
COP	collateral provider
CQS	credit quality step
DBRS	Dominion Bond Rating Service
EC	European Commission
ECAF	European Credit Assessment Framework
ECAI	External Credit Assessment Institution
ECB	European Central Bank
EEA	European Economic Area
EEC	European Economic Community
ELA	Emergency Liquidity Assistance
EMIR	European Market Infrastructure Regulation
EMU	European Monetary Union
ESCB	European System of Central Banks
ESM	European Stability Mechanism
EU	European Union
FCC	fonds communs de créances
FTPL	fiscal theory of the price level
GC	general collateral
GDP	Gross Domestic Product
GLOC	Gresham's Law of Collateral
GNP	Gross National Product
HRL	high-risk lending
ICMA	International Capital Market Association

IFAC	International Federation of Accountants
IMF	International Monetary Fund
ISIN	International Securities Identification Number
LC	liquidity category
LOLR	lender of last resort
LRL	low-risk lending
LTRO	longer-term refinancing operation
MRO	main refinancing operation
MRR	main refinancing rate
NAMA	National Asset Management Agency
NCB	National Central Bank
NPG	no-Ponzi game condition
OMO	open market operation
OMT	outright monetary transactions
PD	probability of default
PVBC	present-value budget constraint
repo	repurchase agreement
RMBD	retail mortgage-backed debt instrument
RMBS	residential mortgage-backed security
SLTRO	supplementary longer-term refinancing operation
SMEs	small and medium enterprises
SMP	Securities Market Programme
SPV	special purpose vehicle
STEP	Short-Term European Paper
Target	Trans-European Automated Real-Time Gross Settlement Express Transfer System
TBTF	too big to fail
TFEU	Treaty on the Functioning of the European Union
TLTRO	targeted longer-term refinancing operation
TVC	transversality condition
UCITS	Undertakings for Collective Investment in Transferable Securities
UN	United Nations

List of Symbols

A	securities purchased by the central bank
b_k	fraction of subsidized bonds in CQS $k \in \{1, 3\}$
c^e	value of contingent explicit liability; cost of government guarantee to eligible assets
$\bar{c}^e$	cost of government guarantee to ineligible asset
c^i	value of contingent implicit liability
D	government debt
d	government debt relative to GDP
G	government spending
g	growth rate of GDP
h	haircut
h_a	add-on haircut
h_{CB}	haircut applied by the central bank
h_e	effective haircut
h_L	haircut applied by a private lender
h_n	nominal haircut
i	market rate of interest; interest rate on government debt
i_L	repo rate; interest rate in collateralized loan
k	capital key of an NCB
L	refinancing loans given by the central bank
M	monetary base
m	initial margin
pb	primary balance relative to GDP
P	price level
p^e_λ	probability of occurrence of contingent explicit liability
p^i_λ	probability of occurrence of contingent implicit liability
p	counterparty success probability
p_A	success probability of security purchased by the central bank
p_L	success probability of central bank refinancing loan
q	collateral success probability
$\hat{q}$	minimum credit rating threshold
R	aggregate surplus in the repo market
R_B	rent of borrowers
R_{CB}	rent of the central bank (Eurosystem)
R_L	rent of lenders
r	real interest rate
s	signal on bond quality

$\hat{s}_k$	minimum rating in CQS $k \in \{1, 3\}$
T	tax revenue
V	present value
v	valuation markdown
Y	GDP
α	return to borrower from outside option
β	discount rate
Γ	transfer from the central bank to the government
Γ_{int}	transfer from the central bank to the government in case of income retention
γ	transfer from the central bank to the government relative to GDP
δ	central bank income from money creation (seignorage)
δ_{as}	seignorage measured by asset-side approach
δ_{fisc}	fiscal seignorage
δ_{mon}	monetary seignorage
δ_{opp}	opportunity cost seignorage
ϵ	misvaluation of bond quality; rating distortion
ζ	lenders' demand for bonds
Θ	set of marketing borrowers
θ	bond quality
θ_α	bond quality threshold for borrowers turning to market
θ_{α_k}	bond against which public repo conditions are pooled within CQS k
$\hat{\theta}_k$	minimum bond quality in CQS k
κ	liquidity of collateral; recovery rate of loan
λ	parameter of Poisson process
μ	lenders' belief on average quality of traded bonds
ξ	residual maturity of collateral asset
π	inflation rate
ρ	bond price
σ	depositor impatience/panic
τ	haircut subsidy provided by the central bank
ν	income retained by the central bank
ν_{req}	retained income required to restore central bank finances
Φ	collateral value of asset/bond; value of explicit government guarantee
Φ_{CB}	collateral value assigned by central bank
Φ_L	collateral value assigned by lender
φ	error in theoretical valuation
χ	(conditional) collateral success probability in case of close links
Ψ	theoretical value assigned to asset/bond
Ω	market value of asset/bond

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1

Introduction

1.1 Motivation

Five counterparties defaulted on refinancing loans from the Eurosystem to the total amount of EUR 10.3 bn when the financial crisis hit Europe in the fall of 2008.[1] According to the European Central Bank (ECB), loans under default were mostly collateralized by assets of limited liquidity that had to be restructured to allow for recovery. Claims unsettled by the restructured collateral assets were deprived from governments that are entitled to National Central Banks' (NCBs) profit. Write-off losses from weakly collateralized refinancing loans that adversely affect governments' budget may not remain an isolated case as the Eurosystem has substantially relaxed its collateral framework during recent years.

The collateral framework is the guiding principle for Eurosystem liquidity provision in terms of both lending and asset purchases. Only eligible marketable assets as specified by the collateral framework qualify for purchases by the Eurosystem (ECB 2011d). Refinancing loans are required to be adequately collateralized (ECB 2012e). Adequacy of collateral implies "[...] first, that the Eurosystem is protected from incurring losses in its credit operations and, second, that sufficient collateral should be available to a wide set of counterparties [...]" (ECB 2007a, pp. 101-2). This manifests the trade-off inherent in the Eurosystem's interpretation of collateral adequacy as it makes two opposing demands on collateral quality: while collateral quality should be sufficiently high to protect the Eurosystem in case of counterparty default (*risk protection*), it should also be sufficiently low to ensure the availability of collateral to counterparties (*collateral availability*).[2] The Eurosystem solves this trade-off by specifying collateral criteria as the "efficient outcome of a cost-benefit analysis" (ECB 2015c, p. 16).

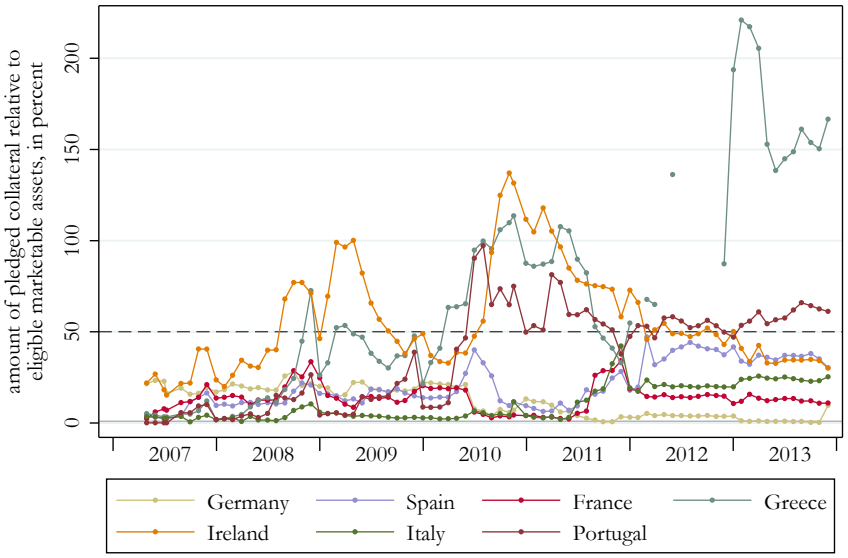
[1] See ECB, "Eurosystem Monetary Policy Operations in 2008," *Press Release*, 5 March 2009, Sibert 2009 as well as Belke and Polleit 2010.

[2] Stipulation for collateral availability is inter alia related to how central banks implement monetary policy. Central banks predominantly relying on lending should ensure a larger availability than central banks focusing on asset purchases (Cheun et al. 2009).

The Eurosystem always deemed eligible a wide range of collateral in its endeavor to ensure collateral availability (TABAKIS and WELLER 2009, ECB 2015c). However, this endeavor was challenged throughout recent crises, which threatened collateral availability and raised concerns about collateral scarcity constraining banks' funding. Figure 1.1 depicts collateral scarcity in selected countries from 2007 to 2013 measured in terms of the amount of pledged collateral relative to marketable assets eligible in a country.[3] While collateral scarcity was absent prior to the financial crisis in all selected countries, it became a pressing issue (interpreted as values larger than 50%, see dashed line) in Greece, Ireland and Portugal and it substantially increased in Italy and Spain. In accordance with collateral availability as the second demand of collateral adequacy, the Eurosystem substantially and successively relaxed its collateral framework to counter country-specific collateral scarcity.[4]

Figure 1.1: Estimated central bank collateral scarcity in selected Eurozone countries

The figure elaborates on the development of central bank collateral scarcity in selected Eurozone countries from 2007 to 2013. Collateral scarcity is measured in terms of the amount of pledged collateral relative to marketable assets eligible in a country. While collateral scarcity was absent prior to the financial crisis in all selected countries, it became a pressing issue (interpreted as values larger than 50%, see dashed line) in Greece, Ireland and Portugal and it substantially increased in Italy and Spain.



Greece: gaps in the time series owing to ineligibility of government-related collateral; see Chapter 3.
Source: author's calculation; European Central Bank, *Eligible Assets Database*.

However, the relaxation of collateral criteria implies that the quality of pledged collateral deteriorates such that the risk exposure of the Eurosystem would increase if the additional collateral risk was not sufficiently hedged. Two broad types of liquidity provision with different risk implications prevail for the Eurosystem, relating to its handling of collateral. First, the Eurosystem provides liquidity by purchasing collateral assets. This gives rise to direct risk since the Eurosystem would have to write off liquidity in case of asset default ("single default"). Second, the Eurosystem provides liquidity based on collateralized loans. This implies indirect risk as liquidity would have to be written off only if both the counterparty and the collateral defaulted ("dou-

[3] See also Section 5.1 for further details. Values larger than 100% are possible as the analysis cannot factor in eligible non-marketable assets, given that no information is available.

[4] See e.g. COEURÉ 2012, LEVELS and CAPEL 2012, SINGH 2013 and ECB 2014a.

ble default"). The relaxation of collateral criteria implies that direct risk from asset purchases increases as the quality of acquired assets declines. Likewise, indirect risk from collateralized loans increases as the quality of risk protection in terms of collateral declines. Prior to the financial crisis, the Eurosystem provided liquidity exclusively by lending against collateral complying with its initially high quality requirements. This is referred to as low-risk lending (LRL). Owing to relaxations of its collateral framework, the Eurosystem altered its liquidity provision towards loans collateralized by low-quality collateral, i.e. high-risk lending (HRL), and asset purchases (AP).

Figure 1.2 mirrors the evolution of Eurosystem liquidity provision from 2007 to 2013. It details the development of the volume of refinancing loans provided against two types of collateral, i.e. *(i)* collateral estimated to having complied with the pre-crisis credit rating threshold (LRL) and *(ii)* collateral of lower credit quality (HRL).[5] Moreover, it illustrates the development of the volume of asset purchases (AP).[6] Volumes are given relative to those in January 2007 to reflect the evolution in liquidity provision by classifying extended liquidity provision in terms of LRL, HRL and AP. The figure indicates that the Eurosystem extended liquidity by LRL in late 2007 when the first tensions in interbank markets occurred. It readopted this type of liquidity provision from the fall of 2008 to the intensification of the sovereign debt crisis in mid-2010. It turned to providing additional liquidity by HRL as well as AP in the summer of 2010 when it likely started to accommodate refinancing loans against collateral of lower credit quality and to purchase assets. In late 2011, it further performed LRL again such that it provided additional liquidity in 2012 and 2013 by AP as well as LRL and HRL.

Relaxations of collateral criteria bear fiscal implications. The Eurosystem successively increased its risk exposure owing to the evolution of liquidity provision, which is closely related to relaxations of collateral criteria. Risk protection deteriorated from LRL against high-quality collateral to HRL against lower-quality collateral (with insufficient risk hedging) to purchases of collateral. Lower risk protection facilitates the likelihood of a central bank bailout, which constitutes a fiscal risk in terms of a contingent government liability that is not contractually agreed. Hence, the monetary policy of the Eurosystem can have effects on the fiscal policy of Eurozone governments when it would have to be adjusted in response to budgetary spillovers from monetary policy. Furthermore, relaxed collateral criteria bear a further fiscal implication when relaxations affect the eligibility of government-guaranteed assets. Amendments to collateral criteria can acknowledge governments' discretion to free up eligible assets via explicit guarantees to otherwise ineligible assets. In this case, amendments shape incentives to initiate new or extend existing explicit government guarantees, i.e. to assume fiscal risk in terms of contingent government liabilities that are contractually agreed.

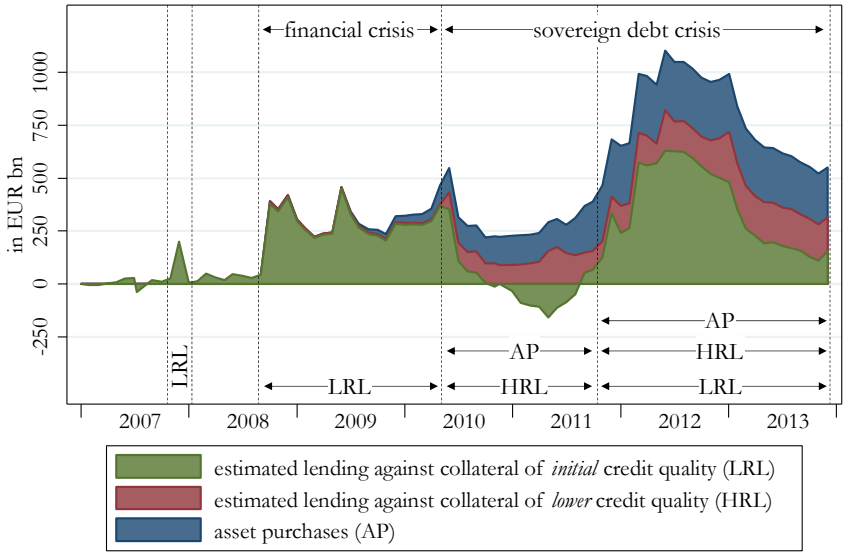
Figure 1.3 elaborates on the hypothetical fiscal implications of the Eurosystem collateral framework by indicating the development of the fiscal position of two aggregates of selected Eurozone

[5] The figure is based on the quality of pledged collateral estimated by the author in Section 5.1. It depicts the development of volume from January 2007 to December 2013 as estimates on collateral credit quality are only available for this period.

[6] NCBs' asset purchases under the so-called agreement on net-financial assets (ANFA) are neglected here as reliable information is scarce and they officially are no monetary policy issue, rather serving investment purposes. See e.g. ANDERSON and STALLINGS 2013 as well as HOFFMANN 2015 on asset purchases under the ANFA.

Figure 1.2: Evolution in liquidity provision of the Eurosystem

The figure elaborates on the evolution in liquidity provision of the Eurosystem from 2007 to 2013. It details volumes of loans against collateral estimated to having complied with the pre-crisis minimum credit rating (LRL) and collateral of lower credit quality (HRL) together with the development of the volume of asset purchases (AP). Volumes are stated relative to the respective volumes in January 2007 to reflect the evolution in liquidity provision of the Eurosystem.



Reference month: January 2007.
Source: author's calculation; National Central Banks; European Central Bank, *Eligible Assets Database*.

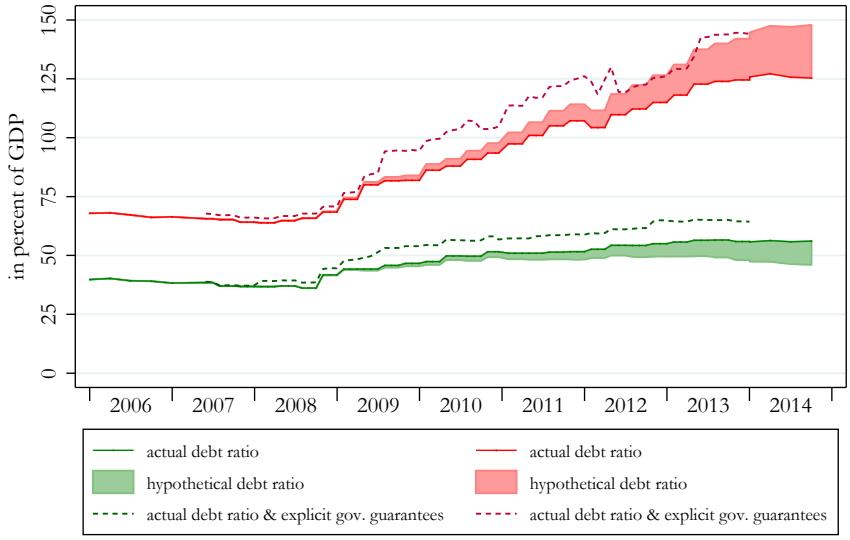
countries (Germany, Netherlands, Finland and Luxembourg as more financially solid countries and Greece, Ireland, Portugal, Spain, Italy and Cyprus as crisis-stricken countries) in terms of the unweighted average government debt ratios from 2006 to 2014.[7] The presumption that amendments to collateral criteria bear fiscal implications implies that this development would have been different if the Eurosystem had not relaxed collateral criteria during recent years. The depicted areas are the result of a counterfactual exercise, providing a very stylized indication of the counterfactual development of debt ratios. Accordingly, they reflect the hypothetical development of government debt in the absence of amendments to collateral criteria. The debt ratio would have been smaller for the aggregate of the more financially sound countries as it is claimed that these countries did not benefit from relaxed collateral criteria. By contrast, the aggregate of crisis-stricken countries is considered as a beneficiary of relaxed collateral criteria such that their debt ratio would have been larger in the absence of relaxed collateral criteria. Moreover, the figure provides the unweighted average of explicit government guarantees in addition to government debt ratios for both country-aggregates (dashed lines) in due consideration of the effect of relaxed collateral criteria on government incentives to give explicit guarantees. It suggests that this more comprehensive measure of government indebtedness departed from

[7] Fiscal sustainability indicators are the obvious alternative for assessing the development of fiscal positions, as pioneered by BLANCHARD 1990 and applied by e.g. the European Commission (EC). See BALASSONE and FRANCO 2000 and CHALK and HEMMING 2000 for discussions. The indicators measure the necessary adjustment of fiscal policy to ensure fiscal sustainability over a given time horizon. Despite their intuitive appeal, quantitative assessments based on forward-looking indicators are flawed as indicators rely on estimates of future developments of variables over an arbitrary time horizon. Fiscal sustainability indicators of the EC are inadequate for assessing the development of fiscal positions as they lack availability and comparability as specific parameters such as the time horizon were adjusted.

debt ratios for both country-aggregates over time as governments extended explicit guarantees inter alia owing to relaxed collateral criteria.

Figure 1.3: Stylized fiscal implications of relaxed Eurosystem collateral criteria

The figure hypothesizes the fiscal implications of relaxed Eurosystem collateral criteria, distinguishing between two aggregates of Eurozone countries. Green refers to the aggregate of financially sound countries while red depicts financially stricken countries. The areas provide a highly stylized indication of the counterfactual development of government debt (in terms of the unweighted average government debt ratio), i.e. the hypothetical development absent of amendments to the collateral framework. It is assumed that government debt would have been lower for the aggregate of financially sound countries and higher for financially stricken countries. Moreover, the figure provides the unweighted average of explicit government guarantees to eligible marketable assets together with government debt for the two aggregates (dashed lines). It suggests that this more comprehensive measure of government indebtedness departed from the progress of debt ratios for both country-aggregates over time as governments extended explicit guarantees inter alia owing to relaxed collateral criteria.



Green: Germany, Netherlands, Finland, Luxembourg.
Red: Greece, Ireland, Portugal, Spain, Italy, Cyprus.
Source: author's calculation; Eurostat; European Central Bank, *Eligible Assets Database*.

1.2 Main Findings, Related Literature and Contributions of the Thesis

The dissertation derives five main findings that evolve from the analysis of the Eurosystem collateral framework and its fiscal implications. The first three findings are related to the collateral framework, while the further two findings seize upon the fiscal implications of amendments to it.

Main Finding 1: The Eurosystem has intensified the frequency of amendments to its collateral framework over recent years. This has broadened the collateral pool both horizontally (quantitatively) and vertically (qualitatively), as well as affecting its composition. A narrative database of amendments to the collateral framework is compiled, revealing that the Eurosystem has intensified the frequency of amendments in response to the financial and the sovereign debt crisis. Amendments were predominantly directed at relaxing collateral criteria. While they were mostly general as a first response to the financial crisis, the Eurosystem has refined activity towards asset type-specific criteria over time. Moreover,

the analysis shows that the Eurosystem has broadened the pool of eligible marketable assets ("collateral pool") both horizontally and vertically. Horizontally, it extended the collateral pool quantitatively, i.e. it deemed eligible additional asset types of initial credit quality. Vertically, the Eurosystem expanded the pool qualitatively by lowering the minimum credit rating threshold for initial types of eligible assets. The investigation of amendments to the collateral framework suggests that the collateral pool has changed both in size and composition. Indeed, an analysis of the collateral pool confirms this suggestion, revealing that amendments have affected the pool with respect to geographical composition, composition by asset type, credit quality of eligible marketable assets, denomination of eligible marketable assets, markets in which eligible assets were traded, fraction of government-guaranteed marketable assets and the average residual maturity of eligible marketable assets.

Main Finding 2: The Eurosystem applies valuation haircuts as the major risk mitigation measure in a simplified fashion based on a reduced set of available information. This implies a subsidization of eligible assets relative to the market and imperfect mitigation of collateral risk. The Eurosystem applies a set of measures to mitigate collateral risk that is specified in the collateral framework. Risk control measures and particularly valuation haircuts as the most important measure were adjusted in response to major exogenous events such as the financial crisis as well as endogenous events such as amendments to the collateral framework. Despite being the major risk mitigation tool, adjustments to haircuts were infrequent and not always specifically related or delayed to observable events. Moreover, the Eurosystem haircut application is associated with three flaws, giving rise to simplified haircuts that neglect available information on asset properties. The negligence of available information stems from *(i)* the application of the first-best rule when the pivotal rating is identified, *(ii)* the sequential application of valuation markdowns and haircuts and *(iii)* the clustering of asset properties. The application of simplified haircuts implies pooling of refinancing conditions, i.e. the alignment of collateral values assigned to assets with different properties. The pooling of refinancing conditions has two implications: first, a fraction of assets is subsidized relative to the market; and second, risk control is imperfect as collateral risk is not fully hedged. This increases the Eurosystem's risk exposure, in particular when collateral criteria are relaxed.

Main Finding 3: The application of simplified haircuts makes the Eurosystem prone to the adverse selection of collateral. This reinforces the increase of the risk exposure and contributes to understanding empirical evidence that the default probabilities of eligible and pledged collateral have developed asymmetrically. The Eurosystem likely attracted collateral assets of relatively low quality owing to the application of simplified haircuts and the pooling of refinancing conditions. This phenomenon of adverse selection of collateral is referred to as Gresham's Law of Collateral (GLOC), according to which high-quality collateral is used on the market while low-quality collateral is pledged with the central bank. The attraction of low-quality collateral would be intensified and beyond the control of the central bank if credit ratings were positively distorted. The adverse selection of collateral facilitates the understanding of empirical evidence that the default probabilities of eligible and pledged collateral have developed asymmetrically in the Eurozone over recent years. While the default probability of eligible marketable assets developed relatively stable from 2007 to 2013, the default

probability of pledged collateral more than trebled over the same period. This indicates that eligible assets were adversely selected to the Eurosystem in line with GLOC, which reinforced the increase in the Eurosystem's risk exposure over recent years.

Main Finding 4: Amendments to uniform collateral criteria in a monetary union bear cross-country fiscal implications, giving rise to risk-sharing and a transfer of fiscal sustainability across heterogeneous countries. The optimal level of collateral criteria from a fiscal perspective is the solution to the trade-off between expected costs and benefits that accrue to the Treasury from amendments to collateral criteria. Relaxed collateral criteria are beneficial to the Treasury as they enhance liquidity in the financial sector, which amplifies demand for government bonds and lowers government borrowing costs. However, they are also costly to the Treasury in terms of a higher probability of central bank bailout, which constitutes an implicit fiscal risk, i.e. a contingent government liability that is not contractually agreed. Specifically, the relaxation of Eurosystem collateral criteria boosted the probability of a central bank bailout by facilitating central bank risk exposure from higher collateral risk, Emergency Liquidity Assistance (ELA) and intra-Eurosystem imbalances. As Eurozone governments bear the cost of potential central bank bailout unequally and shocks to fiscal positions were asymmetric during the sovereign debt crisis, fiscally desired levels of collateral criteria diverged. Divergence was particularly strong as several countries experiencing the largest deterioration in the fiscal position would have only had to contribute little to the central bank bailout. If the central bank relaxed collateral criteria from an initially strict level to the level preferred by crisis-stricken countries, amendments to collateral criteria would affect fiscal positions. Accordingly, they would increase risk-sharing and transfer fiscal sustainability from financially solid countries to crisis-stricken countries.

Main Finding 5: Amendments to collateral criteria bear fiscal implications as changes to the eligibility of government-guaranteed assets shape government incentives to give explicit guarantees to eligible marketable assets. Amendments to the collateral framework have further fiscal implications when they affect the eligibility of government-guaranteed assets. Upon first glance, collateral criteria appear to be a monetary policy issue while government guarantees are a fiscal policy one. However, following further consideration, amendments to the collateral criteria of government-guaranteed assets shape government incentives to initiate new or extend existing explicit guarantees. Explicit guarantees constitute an explicit fiscal risk, i.e. a contingent government liability that is contractually agreed. Collateral criteria are vital for government incentives to grant explicit guarantees when they acknowledge government discretion to create eligible collateral via guarantees. Therefore, a novel rationale characterizes the optimal level of explicit government guarantees from a fiscal perspective by trading off the costs and benefits of giving explicit guarantees. Explicit guarantees to eligible assets bear *(i)* lower expected costs as the government would pay a fraction of the guarantee back to itself via profit distribution in the Eurosystem if the guarantee was called, as well as *(ii)* higher benefits as guarantees facilitate liquidity in the financial sector, which lowers government borrowing cost via the effect of enhanced liquidity on the demand for government bonds (see Main Finding 4). The narrative database of amendments to the collateral framework revealed that the Eurosystem acknowledged government discretion to create collateral via explicit guar-

antees to e.g. own-use uncovered bank bonds. The analysis of explicit government guarantees given to eligible marketable assets from 2007 to 2013 suggests that governments contributed to the provision of additional collateral throughout the financial and sovereign debt crisis. Hence, the Eurosystem collateral framework had a bearing on the accumulation of explicit fiscal risk and contributed to intensify the nexus between governments and the financial sector.

The main findings point to the following strands of the literature, which the dissertation complements.

First, the dissertation adds to the body of literature that analyzes and compares *collateral frameworks of central banks*. This body has recently expanded as several central banks have extensively amended collateral criteria as a monetary policy tool since the onset of the financial crisis. CHAILLOUX et al. 2008a review early responses of major central banks to the financial crisis. CHAILLOUX et al. 2008b and CHEUN et al. 2009 provide surveys of the principles shaping the collateral framework of central banks and track their adaptions during the early stage of the financial crisis. TABAKIS and WELLER 2009 provide a comprehensive overview of the collateral framework of the Federal Reserve, the Eurosystem and the Bank of Japan. More recent comparative studies are provided by ECB 2013a, BIS 2013b and ECB 2014a. A general discussion of central bank collateral frameworks is provided by BINDSEIL and PAPADIA 2009, RULE 2012 and BINDSEIL 2014. GROS et al. 2012 outline the major reason why changes to collateral criteria differed between the Federal Reserve and the Eurosystem. The authors argue that while the early stage of the financial crisis (2007-09) was similar on both sides of the Atlantic, the subsequent period was unique to the Eurozone. Accordingly, the Eurosystem collateral framework was amended the most frequently. First overviews of the Eurosystem collateral framework and its amendments are detailed by HOFMANN 2011, ECB 2013c, SINN 2012, 2014b and ECB 2015c. In-depth surveys and analyses of the amendments were more recently published by EBERL and WEBER 2014a, BELKE 2015 and NYBORG 2015. The dissertation complements and extends recent in-depth investigations by compiling a narrative database comprising all relevant amendments to the Eurosystem collateral framework from 2001 to 2014. It provides detailed information on the chronological sequence of amendments, in general and differentiated by asset type. Moreover, new data provided by the Deutsche Bundesbank is investigated to track the effects of amendments to collateral criteria on the development of the Eurosystem collateral pool as well as national collateral pools. Specifically, the analysis of this data provides innovative insights into the credit quality of eligible assets that were hitherto not available. It also facilitates the distinction between quantitative and qualitative broadening of the collateral pool. Hence, the dissertation records the dimension of quantitative and qualitative broadening of the Eurosystem and national collateral pools, as well as further effects of amendments to the Eurosystem collateral framework on collateral pools.

Second, the dissertation contributes to the literature on *risk management of the Eurosystem*, which has received increased attention with the Eurosystem assuming a riskier monetary policy throughout the financial and sovereign debt crisis. Several important studies are collected in BINDSEIL et al. 2009. BINDSEIL 2009a examines central bank activity during the financial crisis from a risk management perspective. BINDSEIL 2009b provides an overview of the different

types of risk to central banks, particularly from central bank policy operations. BINDSEIL and PAPADIA 2009 argue that the risk of eligible assets can be harmonized and mitigated to the level consistent with central bank risk tolerance by means of appropriate risk mitigation. Asset eligibility should subsequently base on a cost-benefit analysis. GONZÁLEZ and MOLITOR 2009 explore in depth with respect to methodological issues of risk mitigation and credit risk assessment in central bank policy operations. Furthermore, the authors motivate the application of different risk mitigation measures and discuss how they are used by the Eurosystem. TABAKIS and WELLER 2009 compare risk mitigation measures and credit risk assessment in central bank policy operations for the Federal Reserve, the Eurosystem and the Bank of Japan. HEINLE and KOIVU 2009 present an approach to estimate tail risk for a portfolio of collateralized central bank loans. More recent analyses of Eurosystem risk control include BINDSEIL 2014, EBERL and WEBER 2014b, ECB 2015c and NYBORG 2015, among others. The dissertation complements this body of literature by providing a comprehensive survey of Eurosystem risk control measures, their application and development from 2001 to 2014. Valuation haircuts are identified as the principal risk control measure and their quantitative development is tracked from 2001 to 2014 for all eligible asset types. It is shown how the Eurosystem adjusted valuation haircuts in response to major exogenous factors such as the financial and the sovereign debt crisis as well as endogenous factors such as its amendments to the collateral framework. Moreover, shortcomings in the application of valuation haircuts are identified.

Third, the dissertation adds to the literature on *adverse selection of collateral*. This phenomenon is referred to as Gresham's Law of Collateral (GLOC), adapted from "Gresham's law" describing the tendency of bad money to drive out good money (e.g. MACLEOD 1856 and VON HAYEK 1976). The analogy between Gresham's law for money and collateral is narratively established by CHAILLOUX et al. 2008a,b, while the adverse selection of collateral is discussed in SINGH 2013. BINDSEIL 2014 seizes on the phenomenon of GLOC and discusses four measures that central banks could in principle consider to counteract the concentration of low-quality collateral owing to adverse selection. The adverse selection of collateral was first analyzed within a model by EWERHART et al. 2006. The authors derive a preference of borrowers to pledge illiquid assets with the central bank taking into account different pricing of liquidity risk by the market and the central bank. NYBORG et al. 2002 argue that the adverse selection of collateral would be the natural outcome of banks using collateral efficiently owing to heterogeneity in the opportunity cost of collateral pledge. EWERHART and TAPKING 2008 confirm this finding that the least liquid and most risky assets will be deposited with the central bank. The adverse selection of collateral is observed for the Eurosystem by BINDSEIL and PAPADIA 2006 from 1999 to 2005 and by CHAILLOUX et al. 2008b from 2004 to 2007. The latter study also cites the adverse selection of collateral for the Federal Reserve in the outset of the financial crisis. EBERL and WEBER 2013 elaborate on and confirm the adverse selection of collateral for the Eurosystem within a theoretical model. Most recently, FECHT et al. 2015 document adverse selection (referred to as "systemic arbitrage") for German banks' borrowing from the Eurosystem from 2006 to 2010. In this context, systemic arbitrage is also addressed by NYBORG 2015. The dissertation extends the literature on the adverse selection of collateral as follows. First, it addresses GLOC specifically for the Eurosystem within a theoretical model that takes up certain peculiarities

of the Eurosystem collateral framework and risk control. Second, it emphasizes the role of rating agencies for the extent of adverse selection. Third, it adduces descriptive evidence for the occurrence of GLOC in the Eurozone from 2007 to 2013. Finally, the finding of adverse selection of collateral is used to estimate the credit quality of collateral pledged with the Eurosystem. It thereby provides novel insights since the Eurosystem publishes information on the quantity but not the quality of pledged collateral.

Fourth, the dissertation complements and extends the currently small body of literature on *fiscal implications of the Eurosystem collateral framework* that elaborates on spillovers from Eurosystem collateral criteria to fiscal policy.[8] A broad approach is usually taken, analyzing the link between monetary and fiscal policy (and vice versa). Important contributions to this approach include but are not limited to SARGENT and WALLACE 1981, AIYAGARI and GERTLER 1985, KING and PLOSSER 1985, LEEPER 1991, COCHRANE 2001, AFONSO 2008, IZE and OULIDI 2009 as well as WALSH 2010. The link originates from the assumption of different yet inherently linked tasks by the central bank and the government, whereby the central bank performs monetary policy and ensures price stability while the government implements fiscal policy in terms of spending and taxation. Both monetary and fiscal policy can contribute to satisfying the government budget constraint: while fiscal policy can be adjusted in terms of spending and revenue, monetary policy can alter money creation, which affects the transfer of financial means from the central bank to the government. Accordingly, printing money can contribute to alleviate distressed public finances at the cost of inflation. A situation in which fiscal policy is expected to adjust such that the government budget constraint holds while monetary policy is set freely is called a *Ricardian* regime with *monetary dominance*. By contrast, a *non-Ricardian* regime with *fiscal dominance* assumes that monetary policy ensures that the government budget constraint is met. Limited attention has been devoted to the relation between collateral policy and fiscal policy, despite the former growing in importance as it facilitated non-standard monetary policy. Existing analyses are usually narrative and focused on the risk from lending against low-quality collateral and assets purchases (e.g. SIBERT 2009, BUITER and RAHBARI 2012b as well as SINN 2012, 2014b). While this risk can culminate in the need for central bank bailout, this was often negated by the assertion that central banks do not care about their finances as they would always be able to recapitalize themselves through money creation (e.g. DE GRAUWE and JI 2013). The dissertation challenges this assertion and collects evidence suggesting that central banks de facto take their financial position into account. Moreover, it argues that the Eurosystem became particularly prone to central bank bailout owing to the relaxation of collateral criteria. It is unrolled that the Eurosystem put at risk its income from money creation, implicitly lowered the collateral criteria for ELA and facilitated the accumulation of huge intra-Eurosystem balances. Thereby, the Eurosystem increased the expected cost of central bank bailout to governments. Taking into account these costs in the government budget constraint to link collateral and fiscal policy, the dissertation extends the literature by elaborating on the

[8] Accordingly, it only touches the financial and real effects of collateral policy such as the overproduction of low-quality assets and tilts in the composition of bank portfolios. See e.g. BUITER and SIBERT 2005, CHAILLOUX et al. 2008b, CHAPMAN et al. 2010, ASHCRAFT et al. 2011, MILES and SCHANZ 2014, NYBORG and ÖSTBERG 2014, NYBORG 2015, FECHT et al. 2015 and VAN BEKKUM et al. 2015.

optimal level of collateral criteria from a fiscal perspective.[9] It reveals how uniform collateral criteria in a monetary union of heterogeneous countries give rise to risk-sharing and the transfer of fiscal sustainability countries.

Finally, the dissertation contributes to the literature, which addresses the importance of collateral criteria for government incentives to grant explicit guarantees. A novel rationale for government guarantees is presented that differs from the common rationale. DIAMOND and DYBVIG 1983 claim that the government should provide support to illiquid financial institutions, facing a potential run on their deposits owing to panic among depositors, based on the self-fulfilling belief of deposit withdrawal. According to ibid., government guarantees would then constitute a costless and fully effective means to prevent panic-driven bank runs. However, the recent financial crisis suggests that bank runs may not be driven by irrational panic rather caused by deterioration of fundamentals such as economic conditions and the value of bank assets, which gives rise to insolvencies of banks. Moreover, governments experienced hard times in providing sufficient resources for necessary guarantees. In this case, government guarantees cannot fully foreclose the possibility of bank runs; rather, they can entail substantial costs, thus rendering them a potential threat to the government budget. Accordingly, the novel rationale elaborated in the dissertation characterizes the optimal level of government guarantees from a fiscal perspective by trading off the costs and benefits of giving explicit guarantees that are inter alia determined by collateral criteria.

1.3 Structure of the Thesis

The dissertation tells the story of the Eurosystem collateral framework and its fiscal implications in seven chapters, which can be conceptually assigned to two parts. The first part comprises Chapters 2, 3, 4 as well as 5 and elaborates on the Eurosystem collateral framework. The fiscal implications of the collateral framework are investigated in the second part, which contains Chapters 6, 7 and 8. *Chapter 2* provides an introductory overview of the development of Eurosystem monetary policy throughout the financial and sovereign debt crisis. It tracks the crisis mitigation of the Eurosystem and identifies collateral criteria as being crucial to this crisis mitigation, given that it facilitated increased liquidity provision. The Eurosystem mitigates risk from liquidity provision in two steps: first, it requires credit operations to be based on collateral; and second, collateral assets are subject to risk control. Stepwise risk mitigation is reflected in the structure of the dissertation. *Chapter 3* provides an in-depth analysis of the Eurosystem collateral framework. It compiles a comprehensive narrative database of general principles and amendments to the collateral framework. Moreover, the effects of amendments to the collateral framework on eligible marketable assets (collateral pool) are elaborated along several dimensions. *Chapter 4* addresses the Eurosystem risk control of collateral assets and how this was adjusted in response to factors that were exogenous and endogenous to the Eurosystem. Moreover, shortcomings of risk control are identified. *Chapter 5* sheds light on the effects

[9] Naturally, the fiscal perspective is simply one of several, given that collateral criteria can also be considered in terms of monetary policy transmission and financial stability (BINDSEIL 2014). However, the fiscal perspective must not be neglected as central bank collateral first and foremost serves the purpose of risk mitigation to the central bank, the finances of which are closely intertwined with the government budget.

of the Eurosystem collateral framework as well as risk control by tracking the development of credit quality of collateral pledged with the Eurosystem. The model elaborated in this chapter shows that it is rationale for counterparties to pledge collateral of relatively low quality with the Eurosystem while relatively good collateral is pledged on the market (adverse selection of collateral). This suggests that the relaxation of collateral criteria had particularly strong adverse effects. *Chapter 6* formulates the framework for analyzing the fiscal implications of the collateral framework, which is based on the analysis of fiscal sustainability. The common framework of fiscal sustainability under certainty is extended to uncertainty such that it facilitates deriving an intuitive indicator for assessing fiscal implications. *Chapter 7* elaborates on the fiscal implication of collateral criteria that evolves from the close link between collateral criteria, central bank finances and the government budget. It derives the optimal level of collateral criteria from a fiscal perspective and shows that uniform collateral criteria in a monetary union of heterogeneous countries give rise to cross-country fiscal implications. *Chapter 8* addresses the fiscal implication of collateral criteria that originates from the close link between collateral criteria and explicit government guarantees to the financial sector. It shows that the Eurosystem collateral framework involves government discretion to free up collateral by giving explicit guarantees. This discretion is vital to government incentives to grant guarantees. Finally, *Chapter 9* provides a summary and rethinks the Eurosystem collateral framework based on the findings of the dissertation.

2

The Monetary Policy of the Eurosystem and the Growing Importance of the Collateral Framework

This chapter provides an overview of Eurosystem monetary policy, its general principles and its development following the outset of the financial crisis and throughout the European sovereign debt crisis. It also emphasizes the central role assigned to the collateral framework in the crisis mitigation of the Eurosystem. The monetary policy of the Eurosystem prior to the crisis can be stylized as follows: it allotted refinancing credit to counterparties at a variable-rate tender procedure for either one week or three months at a relatively high interest rate against collateral of high quality. After the outset of the financial crisis, the Eurosystem mitigated crisis by fully allotting refinancing credit at a fixed-rate tender procedure for various periods of up to three years at a historically low interest rate against a myriad of collateral of ever-declining quality. In addition, the Eurosystem launched several programs to purchase certain types of assets in the primary and secondary market that complied with its relaxed collateral framework. Therefore, the collateral framework was key, albeit it was less prominent to Eurosystem monetary policy and crisis mitigation as collateral availability became the de facto only constraint to liquidity provision. Therefore, relaxations of collateral criteria facilitated the new style of lending in terms of the full allotment of refinancing credit as well as asset purchases. The chapter is structured as follows. Section 2.1 provides an overview of Eurosystem monetary policy and its crisis measures. Sections 2.2 and 2.3 examine the two types of open market operations (OMOs), i.e. "outright transactions" (asset purchases) and "reverse transactions" (loans), as well as their application. Finally, Section 2.4 carves out that amendments to the Eurosystem collateral framework were crucial as they were fundamental to liquidity provision in terms of loans and asset purchases.

2.1 Overview of the Monetary Policy of the Eurosystem[10]

Article 18.1 of the Statute of the European System of Central Banks (ESCB) and of the ECB allows the Eurosystem to operate in financial markets "to achieve [its] [...] objectives and carry out its tasks" (ECB 2012e, p. 238). For this purpose, the monetary policy kit of the Eurosystem contains three tools: *(i)* OMOs, *(ii)* the minimum reserve system and *(iii)* standing facilities.[11] It applies these tools to steer short-term money market rates and ensure its functioning through the provision of liquidity to commercial banks.[12] Unlike other central banks, the Eurosystem pursues a wide and decentralized implementation of its monetary policy, i.e. interaction between NCB and a multitude of eligible counterparties. In order to be eligible, counterparties have to obey the minimum reserve system and be supervised by an European Economic Area (EEA) national authority, as well as being considered financially sound (see ECB 2015c).[13] The focus is placed upon OMOs in the remainder, as the major monetary policy tool for crisis mitigation.

The Eurosystem performs OMOs via five instruments. The most important is the reverse transaction in which it lends liquidity to counterparties against collateral assets. Second, the Eurosystem can also purchase or sell assets on the market, which it calls outright transactions.[14] Finally, it can issue ECB debt certificates, make foreign exchange swaps and collect fixed-term deposits. These five instruments can be assigned to three kinds of OMOs that differ in their objectives: *(i)* refinancing operations, *(ii)* fine-tuning operations and *(iii)* structural operations. Refinancing operations are performed on a regular basis to facilitate liquidity in financial markets. Fine-tuning operations are performed on an ad-hoc basis with the aim of managing liquidity in the market and steering interest rates, particularly to smooth the interest rate effects of unexpected liquidity fluctuations in the market. Structural operations are applied to adjust market liquidity over the longer term such that the Eurosystem can adapt its structural position towards the financial sector. Table 2.1 depicts the instruments with which the three kinds of OMOs are performed. The focus is placed upon reverse and outright transactions, which have been the dominant instruments of the Eurosystem to mitigate crisis via market intervention.[15]

Reverse transactions are the main instrument as they are used to perform all three kinds of OMO. They play the most important role in the Eurosystem's refinancing operations and are applied based upon either a repurchase agreement (repo) or a collateralized loan. In a repo,

[10] For further details on the response of the Eurosystem to the financial crisis, see among many others e.g. ECB 2010c,d, Trichet 2010 and Sinn 2012, 2014b. For its response to the European sovereign debt crisis, see e.g. Cour-Thimann and Winkler 2013, Claeys 2014 and Sinn 2014b. Moreover, the annex of the monthly bulletins of the ECB provides a comprehensive record and chronology of monetary policy measures of the Eurosystem.

[11] For a comprehensive explanation of the Eurosystem's monetary policy framework, see ECB 2015b, commonly referred to as "General Documentation".

[12] More specifically, OMOs serve the purpose of steering interest rates, managing market liquidity and signaling the monetary policy stance. The minimum reserve system aims at stabilizing money market interest rates and creating/enlarging structural liquidity shortage. Standing facilities serve the purpose of providing or absorbing overnight liquidity, signaling the monetary policy stance and bounding overnight interest rates.

[13] Exceptions are possible, e.g. for branches of non-EEA banks within the Eurozone. Furthermore, operational criteria by the respective NCB have to be met.

[14] There is no general restriction on the market in which assets are purchased, i.e. purchases in both the primary and secondary market are permitted. However, according to ECB 2012e, Article 21.1), the Eurosystem is restricted to purchasing government bonds only in the secondary market.

[15] For details on foreign exchange swaps, fixed-term deposits and the issuance of ECB debt certificates as the other instruments to perform OMOs, see ECB 2011d.

Table 2.1: Kinds of open market operations and available instruments

The table shows the instruments by which the Eurosystem can perform the three kinds of OMOs. Reverse and outright transactions have been the dominant instruments to mitigate crisis. While reverse transactions can be used for all three kinds of OMOs, outright transactions can exclusively be performed as a structural operation.

Kind of OMO	Instrument	Purpose
refinancing operation	*reverse transaction*	steer short-term interest rates, manage liquidity, signal monetary policy stance, provide long-term refinancing
fine-tuning operation	*reverse transaction*, foreign exchange swap, fixed-term deposit	manage liquidity, smooth effects on interest rates of unexpected liquidity fluctuations
structural operation	*reverse transaction*, *outright transaction*, issuance of ECB debt certificate	adjust structural position of the Eurosystem towards financial sector

Source: author's compilation; European Central Bank.

ownership of an asset is transferred from the borrower to the lender together with an agreement on reversing the transaction through a retransfer of the asset at a future point in time. By contrast, in a collateralized loan, ownership of the asset is retained by the borrower and the lender receives an enforceable security interest over the asset.[16] In the remainder of this chapter, reverse transactions are referred to as *loans* for simplicity.

The other instrument to perform OMOs that is investigated is outright transactions. They are exclusively performed for structural operations, usually by NCBs, although the Governing Council of the ECB can decree the ECB to perform outright transactions when deemed necessary. Akin to reverse transactions in terms of repos, outright transactions involve a transfer of ownership, albeit with no envisaged reverse transfer of ownership. In the remainder of this chapter, outright transactions are labeled as *asset purchases* for simplicity.

The onset of the financial crisis in the fall of 2008 substantially altered the execution of OMOs, particularly with respect to loans (in terms of reverse transactions) and asset purchases (in terms of outright transactions). This is illustrated in Figure 2.1 for the period from 2008 to 2014.[17] While amendments above the timeline apply to loans, actions below are related to asset purchases. The Eurosystem initiated five asset purchase programs between 2008 and 2014, i.e. the first Covered Bond Purchase Programme (CBPP), the Securities Market Programme (SMP), the second and third CBPP as well as the Asset-Backed Securities Purchase Programme (ABSPP). Moreover, and as an immediate response to market turmoil in October 2008, the Eurosystem performed numerous amendments to its lending operations, especially with respect to the maturity of loans and assets deemed eligible as collateral. Hence, maturities were successively extended, e.g. in October 2008, when the maturity of longer-term refinancing operations (LTROs) was prolonged from three to six months. Furthermore, collateral criteria were extensively amended, most prominently in October 2008 when the minimum credit rating threshold for eligible assets

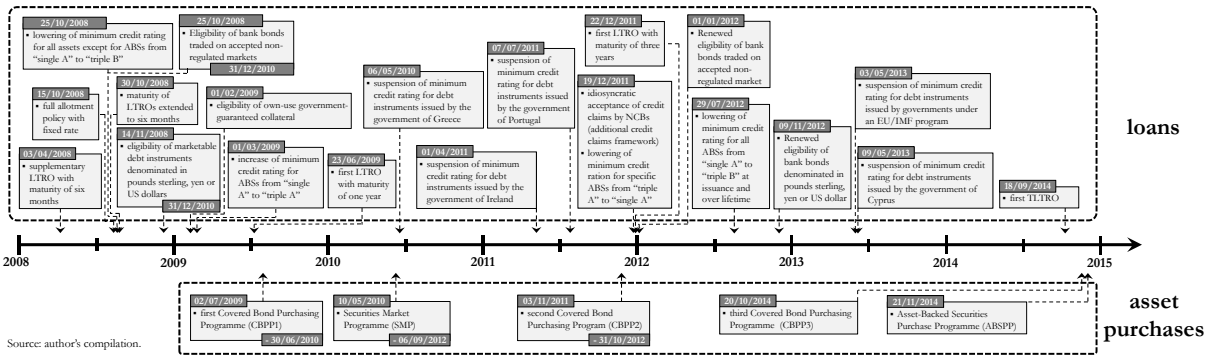
[16] See Chapter 5 for further distinction between repurchase agreements and collateralized loans.

[17] Changes to the interest rate applied to loans are also a major amendment. For the sake of clarity, interest rate changes are not reflected in Figure 2.1 but are addressed in Section 2.3.

was lowered for the first time. Figure 2.1 provides a *qualitative* indication for the assessment that Eurosystem crisis management between 2008 and 2014 predominantly involved accommodating the conditions for loans complemented by asset purchases.

Figure 2.1: Development of the implementation of loans and asset purchases

The figure depicts the major amendments to the implementation of OMOs by means of loans and asset purchases from 2008 to 2014. Amendments to loans are shown above the timeline while major events with respect to asset purchases are given below the timeline. The figure indicates *qualitatively* that the Eurosystem mitigated crisis predominantly by adjusting conditions for loans complemented by asset purchases.



A *quantitative* indication for this assessment is provided by Figure 2.2, which shows the development of the volume of Eurosystem's loans and asset purchases from 1999 to 2014.[18] The volume of loans substantially increased following the onset of the financial crisis and subsequently remained at a high level, before returning to its pre-crisis level in mid-2011. Thereafter, the reintensification of the European sovereign debt crisis led to an even larger increase in the volume of loans culminating in mid-2012. By contrast, asset purchases did not take place earlier than July 2009, when the Eurosystem set up its first asset purchase program directed at covered bonds. The volume of asset purchases increased during the onset of the European sovereign debt crisis in mid-2010. Thereafter, four programs directed at different asset types followed and the purchase volume increased accordingly, particularly after the sovereign debt crisis reintensified. The following two sections take a closer look at the development of asset purchases and loans, i.e. the blue and red areas in Figure 2.2.

2.2 Asset Purchases[19]

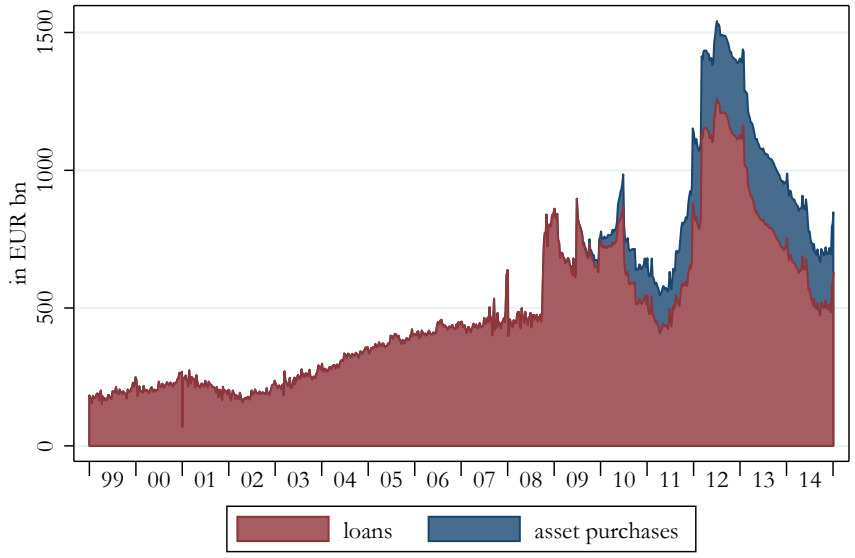
Article 18.1 of the Statute of the ESCB and of the ECB allows the Eurosystem to operate in financial markets inter alia by performing outright transactions, i.e. by purchasing and selling assets (ECB 2012e). Hence, asset purchases are a standard instrument to perform OMOs, although their application is intended within structural operations only such that their frequency is not standardized. From a legal perspective, asset purchases imply a full transfer of owner-

[18] Loans comprise liquidity provided by the Eurosystem via main refinancing operations (MROs), LTROs, fine-tuning reverse operations, structural reverse operations, marginal lending facility and credits related to margin calls. See also Figure 2.5.

[19] NCBs' asset purchases under the so-called ANFA are neglected here as they were discovered very recently and officially are no monetary policy issue, rather serving investment purposes. See e.g. Anderson and Stallings 2013 as well as Hoffmann 2015 on asset purchases under the ANFA.

Figure 2.2: Volume of loans and asset purchases

The figure illustrates the volume of loans and asset purchases of the Eurosystem from 1999 to 2014. Having moderately risen prior to the financial crisis, the volume of loans substantially increased after *(i)* its onset (October 2008) and *(ii)* the reintensification of the European sovereign debt crisis (mid-2011). The Eurosystem purchased assets as of July 2009. The figure *quantitatively* confirms the qualitative indication (Figure 2.1) that the Eurosystem mitigated crisis predominantly via loans complemented by asset purchases.



Source: author's illustration; Euruopean Central Bank.

ship from the selling counterparty to the Eurosystem at a price in accordance with best market practice.[20] A priori, the Eurosystem does not impose any restriction on the range of counterparties from which it may acquire assets. In general, the Eurosystem purchases assets based upon bilateral transactions, meaning that it applies no tender within such transactions. The transactions are usually carried out by the NCBs on instruction from the ECB, although the ECB can purchase the assets itself under exceptional circumstances. Only eligible marketable assets as defined by the Eurosystem's collateral framework are to be purchased. Since the Eurosystem considers asset purchases as part of its common monetary policy, purchased assets are held to maturity. They are initially valued at acquisition cost and later on at amortized cost, i.e. at book value. The Eurosystem purchases assets on the market as any other investor and hence it does not inherently receive preferable treatment in the event of asset default.[21]

Table 2.2 seizes on the five asset purchase programs launched by the end of 2014 (Figure 2.1), summarizes the programs in chronological order and gives the respective targeted asset type, the start and end dates as well as the peak volume. Overall, the Eurosystem purchased assets to the amount of EUR 328.7 bn by the end of 2014. Among these assets, 32.8% (EUR 107.7 bn) were covered bonds acquired under CBPPs 1-3, only 0.5% were Asset-Backed Securities (ABSs) purchased under the ABSPP and 66.7% were government bonds acquired under the SMP.

While Table 2.2 provides only peak volumes, i.e. the highest volume of assets purchased under the respective program, the left panel of Figure 2.3 reveals the development of purchase volumes

[20] For this and the following general principles of asset purchases, see ECB 2011d.

[21] Nevertheless, the ECB received preferable treatment in the Greek debt restructuring of 2012, cf. e.g. Gulati et al. 2013, Sinn 2014b as well as Trebesch and Zettelmeyer 2014.

Table 2.2: Overview of asset purchase programs

The table lists the asset purchase programs of the Eurosystem in chronological order. Three programs were targeted at covered bonds, of which only the last one remains ongoing. The latest purchase program was launched at the end of 2014 and directed at ABSs. The most important program was the SMP, which was targeted at government bonds. It was started in May 2010 and terminated in September 2012 with a peak volume of EUR 219.3 bn.

Program	Asset Type	Start Date	End Date	Peak Volume[a]
CBPP1	covered bonds	02/07/2009	30/06/2010	EUR 61.7 bn
SMP	government bonds	10/05/2010	06/09/2012	EUR 219.3 bn
CBPP2	covered bonds	03/11/2011	31/10/2012	EUR 16.4 bn
CBPP3	covered bonds	20/10/2014	ongoing[a]	EUR 29.6 bn
ABSPP	ABSs	21/11/2014	ongoing[a]	EUR 1.7 bn

[a] By the end of 2014.
Source: author's compilation; European Central Bank.

under the respective programs over time. The right panel shows the composition of purchases by asset types. It is apparent that after the SMP was launched, government bonds accounted for the lion's share of acquired assets. The remainder of this section investigates the purchase programs for the three types of assets separately, focusing on the explanation of the developments given in Figure 2.3.

2.2.1 Covered Bond Purchase Programmes (CBPPs)

By the end of 2014, the Eurosystem had launched three purchase programs directed at covered bonds.[22] Although the names of the programs differ only in the digit indicating their order, technical features have substantially differed, particularly between the first two and the last CBPP.[23] Table 2.3 provides an overview of the features and highlights the differences of the third CBPP. All three programs were targeted at euro-denominated covered bonds issued by financial institutions located in the Eurozone. These bonds had to have a first-best rating of "triple B" to be eligible for purchase.[24] In contrast to the first two CBPPs, CBPP3 was set up broadly.[25] This manifests for instance in the duration of *at least* 24 months of CBPP3 (in contrast to 12 months for CBPP1 and 2) and the absence of a target volume. Moreover, while CBPP1 and 2 were directed towards covered bonds of certain maturities and minimum values, neither a targeted maturity nor a minimum value was specified for CBPP3. Finally, whereas all three programs have been targeted at covered bonds in both the primary and secondary market,

[22] For the role of covered bonds in the Eurozone, see ECB 2008a; for the CBPPs and market impacts, see Beirne et al. 2011 and Szczerbowicz 2014.

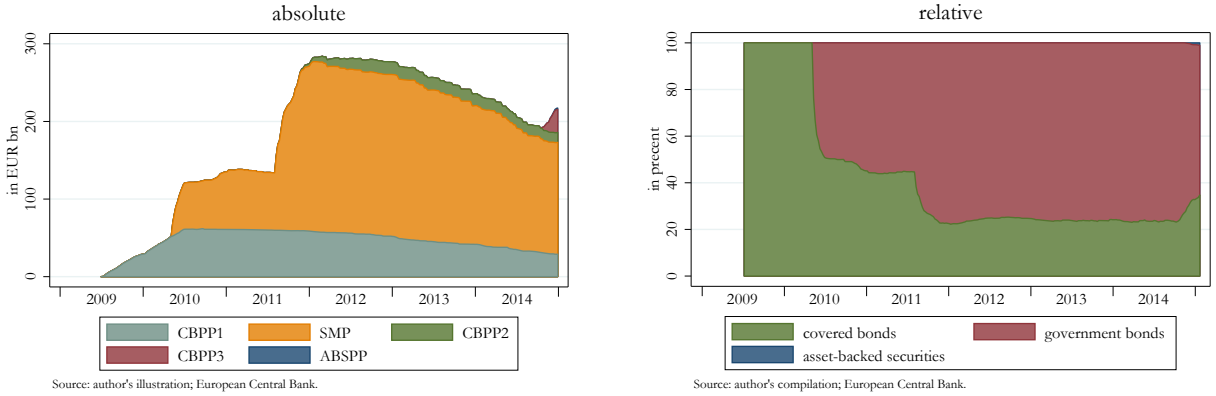
[23] For the technicalities of CBPP1 to CBPP3, cf. ECB 2009, ECB 2011b and ECB 2014b.

[24] This corresponds to credit ratings equivalent to BBB-/Baa3/BBBL; for the harmonized rating scale of the Eurosystem that matches ratings over rating agencies, see Section 3.1.4.3. For CBPP1, a first-best rating of AA/Aa2 was laid down "as a rule" (ECB 2009, p. 19). However, the rating could not be lower than BBB-/Baa3/BBBL, which hence was the actual minimum rating.

[25] The only restriction relative to the previous programs was determined in terms of an issue share limit of 70% for all covered bonds acquired under the CBPP3. For covered bonds being issued in Greece or Cyprus, this limit was 30%. This means that the Eurosystem does not purchase more than 70% or 30%, respectively, of any given bond issuance/International Securities Identification Number (ISIN).

Figure 2.3: Composition of asset purchases

The left panel shows the development of the nominal value of assets purchased under the five programs from 2009 to 2014. It reveals that covered bonds acquired under the CBPP1 were accumulated until July 2010, after which their nominal value continuously decreased. The value of covered bonds acquired under the CBPP2 and 3 and of ABSs purchased under the ABSPP was rather small until the end of 2014. Two phases can be identified with respect to government bond purchases under the SMP. In the first phase (05/2010 to 08/2011), the Eurosystem bought bonds issued by the governments of Greece, Ireland and Portugal. The purchase of Italian and Spanish government bonds initiated the second phase (as of 08/2011), which was more important in quantitative terms.



Source: author's illustration; European Central Bank.

Source: author's compilation; European Central Bank.

CBPP3 also allows for the purchase of retained covered bonds directly from issuers.[26] The relaxations of eligibility requirements may explain the observation that the Eurosystem bought substantially more bonds in the first month under the CBPP3 (EUR 12.7 bn) than under the previous CBPPs (EUR 4.2 bn and EUR 1.6 bn, respectively).

2.2.2 Securities Market Programme (SMP)

The SMP was the second asset purchase program and the first directed at government bonds.[27] First government bond purchases were undertaken in May 2010 in the secondary market, prompting a full discussion on whether the Eurosystem would be legally allowed to perform such purchases.[28] The SMP was terminated by the Eurosystem's announcement of outright monetary transactions (OMT) in September 2012. By the terminal date, NCBs acquired government bonds in strict proportion to their shares in ECB capital in the total amount of more than EUR 200 bn in two phases (left panel of Figure 2.3). In the first phase, lasting from May 2010 to August 2011, the Eurosystem bought bonds issued by the governments of Greece, Ireland and Portugal. The decision to also buy Italian and Spanish government bonds initiated the second phase as of August 2011. Government bond holdings decreased after a peak volume of almost EUR 220 bn in February 2012, amounting to EUR 144 bn by the end of 2014. The holdings can

[26] According to ECB data, the fraction of covered bonds purchased under the CBPP2 in the primary market increased from 15% in November 2011 to 37% in October 2012. For CBPP3, the share of purchases in the primary market during the first month of the program amounted to 24%.

[27] For details on the SMP, see ECB 2010a. For studies of the SMP and its impacts, see e.g. Manganelli 2012, Eser and Schwab 2013, Ghysels et al. 2014 as well as Trebesch and Zettelmeyer 2014. See e.g. Meaning and Zhu 2011 as well as Glick and Leduc 2012 for market impacts of central bank asset purchases.

[28] These discussions were mainly concerned with the question of whether purchases of government bonds would be compatible with Article 123 of the Treaty on the Functioning of the European Union (TFEU) (cf. EU 2012), which prohibits direct purchases of government bonds by the Eurosystem. See e.g. Sinn 2014a as well as Buiter and Rahbari 2012b for opposing views. See also Fuest 2013.

Table 2.3: Comparison of operational criteria for the Covered Bond Purchase Programmes

The table compares the operational criteria for the three purchase programs targeted at covered bonds. Provisions made for CBPP3 differing from those for previous programs are highlighted. Most importantly, CBPP3 has a longer duration and no target volume was specified. Moreover, the Eurosystem acquires retained covered bonds under the CBPP3 and neither a targeted maturity nor a minimum volume of covered bonds was specified.

	CBPP1	CBPP2	CBPP3
Duration	12 months	12 months	**at least 24 months**
Target Volume	EUR 60 bn	EUR 40 bn	**none**
Peak Volume	EUR 61.7 bn	EUR 16.4 bn	n/a
Allocation of Purchases	"across the Eurozone"	"across the Eurozone"	"carried out progressively by the ECB and the NCBs"
Market	primary and secondary	primary and secondary	primary and secondary
Purchase of Retained Bonds	no	no	**yes**
Guiding Eligibility Principle	collateral framework	collateral framework	collateral framework
Currency	EUR	EUR	EUR
Maturity	between 3 to 10 years	up to 10.5 years	**none**
Minimum Rating	first-best rating of AA/Aa2 as a rule; in any case not below "triple B"	first-best rating of "triple B"	first-best rating of "triple B"
Minimum Value	EUR 500 mn as a rule; in any case not below EUR 100 mn	EUR 300 mn	**none**
Purchases per Bond Issuance	no limit	no limit	**70% per ISIN; 30% in case of Greek and Cypriot covered bonds**

Source: author's compilation; European Central Bank.

be expected to continuously decrease over the coming years as the Eurosystem intends to hold purchased government bonds to maturity.

Table 2.4 indicates the fractions according to which the Eurosystem bought government bonds from the five countries based on end-of-year government bond holdings.[29] Accordingly, Italian government bonds accounted for almost half of the bonds acquired under the SMP, followed by Spanish (about 20%), Greek (about 15%), Portuguese (about 10%) and Irish government bonds (about 6%). Moreover, Table 2.4 details the average maturity of purchased government bonds. The average maturity of total government bond holdings amounted to 4.3 years by the end of 2012 and slightly decreased to 3.9 and 3.7 years by the end of 2013 and 2014, respectively. The Eurosystem sterilized government bond purchases to avoid inflationary pressure (via the effect of bond purchases on the monetary base). Accordingly, the Eurosystem offset acquisitions by weekly fine-tuning operations equal to the volume of government bonds held, hence leaving the monetary base unaffected.[30] The Eurosystem suspended these fine-tuning operations as of 10 June 2014. The SMP was terminated with the decision for OMT on 6 September 2012. By the end of 2014, government bond purchases under the OMT had not yet taken place.

Table 2.4: Details on government bond holdings under the Securities Market Programme

The table presents information published by the ECB on the holdings of government bonds from Ireland, Greece, Spain, Italy and Portugal. The largest fraction are Italian government bonds, followed by Spanish, Greek, Portuguese and Irish bonds. Overall, the Eurosystem held EUR 218 bn of government bonds at the end of 2012, which subsequently decreased to EUR 185.7 bn (end of 2013) and EUR 149.4 bn (end of 2014). The average residual maturity of government bond holdings amounted to 3.7 years at the end of 2014.

	Nominal Value[a]			Ø Residual Maturity[b]		
	end-2012	end-2013	end-2014	end-2012	end-2013	end-2014
Ireland	14.2 (6.5%)	9.7 (5.2%)	9.7 (6.5%)	4.6	5.3	4.3
Greece	33.9 (15.6%)	27.7 (14.9%)	19.8 (13.3%)	3.6	3.4	3.5
Spain	44.3 (20.3%)	38.8 (20.9%)	28.9 (19.3%)	4.1	3.6	3.8
Italy	102.8 (47.2%)	89.7 (48.3%)	76.2 (51%)	4.5	4.1	3.8
Portugal	22.8 (10.5%)	19.8 (10.7%)	14.9 (10%)	3.9	3.4	3.3
Total	218	185.7	149.4	4.3	3.9	3.7

[a] in EUR bn; relative values in brackets (deviations possible owing to rounding).
[b] in years.
Source: author's calculation; European Central Bank.

2.2.3 Asset-Backed Securities Purchase Programme (ABSPP)

The last asset purchase program initiated by the Eurosystem by the end of 2014 was directed at ABSs (see ECB 2015a). In the initial phase, the ECB intended to acquire ABSs on its own,

[29] The ECB does not publish detailed data on purchased government bonds. See Barclays Capital 2012 and Sinn 2012, 2014b for inferred asset purchases by country over time. There, it is assumed that the Eurosystem bought government bonds broadly in proportion to the size of the underlying bond markets. This implies that the Eurosystem purchased about 50%, 25% and 25%, respectively, of Greek, Irish and Portuguese government bonds during the first phase, as well as 66% and 33%, respectively, of Italian and Spanish government bonds (and a very small amount of Portuguese and Irish bonds) during the second phase. See also Trebesch and Zettelmeyer 2014.

[30] These weekly fine-tuning operations were performed as fixed-term deposits, see Table 2.1.

whereas later on purchases will be undertaken in a decentralized fashion by the NCBs. ABSs shall be purchased in the primary and secondary market from counterparties eligible for regular monetary policy operations and counterparties used by the Eurosystem for the investment of their euro-denominated investment portfolios, as well as entities deemed eligible by ECB's Governing Council on a case-by-case basis. The Eurosystem intends to purchase euro-denominated ABSs that are issued in the Eurozone and comply with its collateral framework. ABSs must have a second-best rating of "triple B" to be eligible for purchase. However, this rating requirement is waived for ABSs issued in Greece and Cyprus in compliance with the suspension of the minimum rating requirement for these two countries in the collateral framework (see Section 3.2.2). Akin to asset purchases under the CBPP3, there is neither a specified target volume nor a minimum issuance volume. The Eurosystem applies issue share limits of 70% in general and 30% to those ABSs issued in Greece and Cyprus. ABSs holdings purchased under the ABSPP amounted to EUR 1.7 bn by the end of 2014 (see European Central Bank 2015a).

2.3 Loans

The Eurosystem regularly conducts OMOs as refinancing operations to steer short-term interest rates and market liquidity (cf. Table 2.1).[31] Refinancing operations are performed as MROs and LTROs, for which the same collateral assets are eligible. MROs are the regular liquidity-providing transactions, performed weekly with a usual period of one week. LTROs are performed monthly and usually have a period of three months. For both cases, the Eurosystem announces whether it wants to distribute liquidity through a fixed or variable-rate tender. In the former, banks bid the amount of money they want to borrow at a predefined interest rate, while in the latter, they bid the amount and the interest rates at which they want to borrow. Refinancing operations are performed in terms of reverse transactions (cf. Table 2.1). NCBs have the option to conduct reverse transactions as repos or collateralized loans (ECB 2015b).

Within a (liquidity-providing) repo, the NCB and the counterparty agree on two transfers at two distinct points in time. Initially, the NCB buys an asset from the counterparty and at some predefined date in the future the transaction is reversed as the counterparty repurchases the asset from the NCB at a specified price.[32] Hence, legal ownership of the asset is transferred to the NCB for a limited period of time. The counterparty effectively acts as the borrower and the NCB as the lender. The interest rate applied to the repo is implied by the difference between the sale and repurchase price.

The second possible way to perform a reverse transaction is a collateralized loan, i.e. the NCB makes a loan to a counterparty that is secured by assets. Collateral assets are retained by the counterparty and ownership is only transferred to the NCB in case of counterparty default. In practice, assets pledged as collateral have to be stored at a safe custody account of the responsible

[31] Besides refinancing operations, the Eurosystem provides liquidity via fine-tuning reverse operations, structural reverse operations, marginal lending facility and credits related to margin calls. However, these lending practices play only a minor role in the Eurosystem (see Figure 2.5). Moreover, NCBs can provide ELA to solvent yet illiquid counterparties that lack eligible collateral. The Eurosystem considers ELA as not being part of the single monetary policy. See Section 7.3.2 for a further discussion.

[32] For further details on repos, see e.g. Duffie 1996 and Garbade 2006. Repos and particularly their use and importance in the European interbank market is further investigated in Chapter 5 and esp. Section 5.2.

NCB at a clearing and depositary institution. To collateralize a loan, the counterparty can choose to use either the earmarking system in which each pledged asset is earmarked for the specific transaction or a pooling system in which pledged assets are consolidated. Collateral assets are valued in terms of an adjusted market value that needs to exceed provided liquidity over the entire period of the loan.[33] Adjustment of the market value is based on the application of a haircut, which serves as risk control to the Eurosystem as it reflects inter alia credit risk, liquidity and maturity of the security.[34] The NCB credits the adjusted market value to the collateral account of the counterparty, which can subsequently borrow to this extent. In case of counterparty default, the NCB can liquidate the collateral to settle its claims in terms of principal and interest as well as administrative cost. In case of correct risk mitigation, the liquidation value is adequate to settle the claims. Any higher proceeds belong to the counterparty while any residual remains outstanding if only part of the claim can be met.

Repos and collateralized loans are economically similar.[35] Repos de facto represent collateralized loans since the NCB temporarily receives collateral in return for provided liquidity. The main difference is that ownership of the collateral is transferred in case of repos, whereas the borrower retains ownership in collateralized loans. Each NCB decides individually whether reverse transactions are performed as repos or collateralized loans.[36] Figure 2.4 reveals how NCBs performed reverse transactions at the end of 2014. It shows that only five out of 19 NCBs accept repos with counterparties. The NCBs of Belgium, Italy, Luxembourg and Spain permit both repos and collateralized loans, while the NCB of Estonia uses repos exclusively. 18 NCBs perform refinancing operations as collateralized loans with 14 NCBs using exclusively this type of transaction. Hence, the vast majority of NCBs perform refinancing operations as collateralized loans, exposing the Eurosystem to potential tedious legal issues as collateral assets remain with the counterparty and have to be transferred in case of counterparty default.

The red area in Figure 2.2 indicates that the Eurosystem substantially extended liquidity provision via reverse transactions (in terms of repos and collateralized loans) after the onset of the financial crisis and throughout the European sovereign debt crisis. The substantial extension was rendered possible by changes to the following six determinants of credit terms, which are key to any loan or repo and are examined in the following:[37]

1. maturity;
2. interest rate;
3. counterparty;
4. amount;
5. collateral;
6. haircut.

The Eurosystem already extended *maturities* prior to the onset of the financial crisis in the fall of 2008 (cf. Figure 2.1). In April 2008, the Eurosystem introduced supplementary longer-term refinancing operations (SLTROs) with a maturity of six months, i.e. doubling the regular

[33] Depending on whether earmarking or pooling is used, this has to be ensured for each individual transaction or a counterparty in total.

[34] See Chapter 4 for an extensive discussion of risk control of the Eurosystem in general and the application of haircuts in specific.

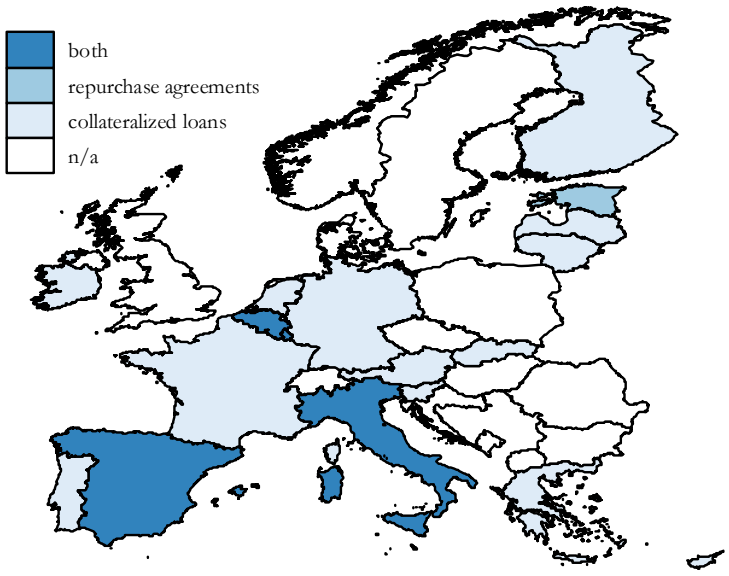
[35] See Ruchin 2011 for a comparison of repos and collateralized loans from a legal perspective. Additional differences between repos and collateralized loans are addressed in Section 5.2 when repos in the interbank market are compared to collateralized loans from the central bank.

[36] The decision usually depends on the market practice of the particular NCB and peculiarities of its national legislation.

[37] See also Adrian et al. 2013 for the determinants and Figure 2.1 for the amendments.

Figure 2.4: How NCBs perform reverse transactions

The figure reveals how NCBs perform reverse transactions. The decision lies with the NCBs to perform them as repurchase agreements and/or collateralized loans (ECB 2015b). The vast majority of NCBs apply collateralized loans only, whereas only four NCBs allow for both types and only Estonia favors repurchase agreements.



Source: author's compilation based on information provided to the author by National Central Banks.

maturity of LTROs.[38] Thereafter, the Eurosystem extended maturities successively, introducing 12- and 36-month terms for LTROs. The first 12-month LTRO tender was settled in June 2009, before two 36-month LTROs followed in December 2011 and February 2012. Moreover, the Eurosystem introduced additional targeted longer-term refinancing operations (TLTROs) with a maturity of up to four years and an early repayment option, the first of which was settled in September 2014. The aim of TLTROs is to support bank lending such that liquidity provision is conditional on counterparties' outstanding loans and net lending. The extension of maturities had two major effects, which are illustrated in Figure 2.5.[39] The figure illustrates the development of lending volumes to eligible counterparties with respect to maturity. First, the left panel reveals a shift from MRO- to LTRO-based lending, i.e. counterparties replaced short-term funding by longer-term funding.[40] Liquidity was predominantly granted via MROs prior to the financial crisis with about three quarters. However, the tide turned with the onset of the financial crisis. By the end of 2014, about 80% of lending took place via LTROs and in May 2011 almost exclusively via LTROs (about 96%). Second, the right panel zooms into the crises times, also revealing a shift within longer-term funding. The successive extension of maturities induced counterparties to draw liquidity via LTROs with the respective longest maturity. By the end of 2014, liquidity was almost solely provided via the three-year LTROs.

[38] The second SLTRO tender with a maturity of six months was settled in July 2008 and various followed in 2009.

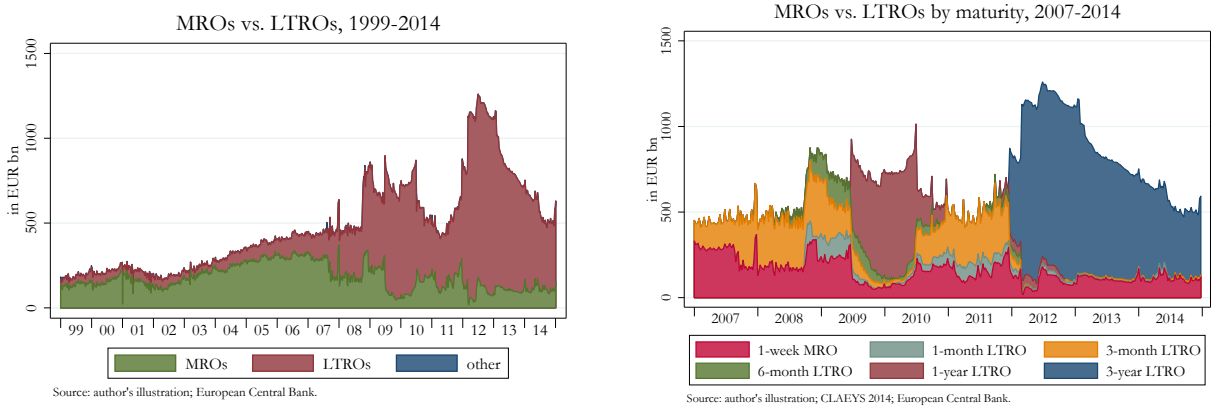
[39] Note that three-year LTROs comprise TLTROs in Figure 2.5.

[40] "Other" comprises fine-tuning reverse operations, structural reverse operations, marginal lending facility and credits related to margin calls.

Hence, the extension of maturities had two effects: first, counterparties switched from MRO- to LTRO-based funding; and second, they drew liquidity from LTROs with the longest maturity.[41]

Figure 2.5: Composition of refinancing loans according to maturity

The figure illustrates the development and composition of loans and how they were affected by the extension of maturities. The left panel indicates that the extension induced a shift in funding from MROs to LTROs. The right panel reveals that this shift was intensified between 2007 and 2014 as counterparties drew liquidity via LTROs with the longest maturity.



Source: author's illustration; European Central Bank.

Source: author's illustration; CLAEYS 2014; European Central Bank.

Together with the extension of maturities, the Eurosystem substantially lowered the *interest rate* applied in lending, i.e. the main refinancing rate (MRR). Figure 2.6 details the development of the MRR from 1999 to 2014. There was large variation in the MRR, which was lowered successively after the financial crisis hit. While the end-of-month average MRR amounted to 3.1% between January 1999 and September 2008, it plummeted to 0.94% between October 2008 and December 2014. At the end of 2014, the interest rate reached a historical low of 0.05%. This development spurred the substantial increase in Eurosystem lending, as depicted in Figure 2.2.

The Eurosystem accounts for a wide range of *counterparties* eligible as the third determinant of credit terms. As explained above, eligible counterparties have to obey the minimum reserve requirement, be supervised by an EEA national authority and be considered financially sound. By the end of 2014, the ECB listed 8,296 monetary financial institutions in the European Union (EU), 5,555 (67%) of which are subject to and not exempt from the Eurosystem's minimum reserve requirement and hence are deemed eligible counterparties.

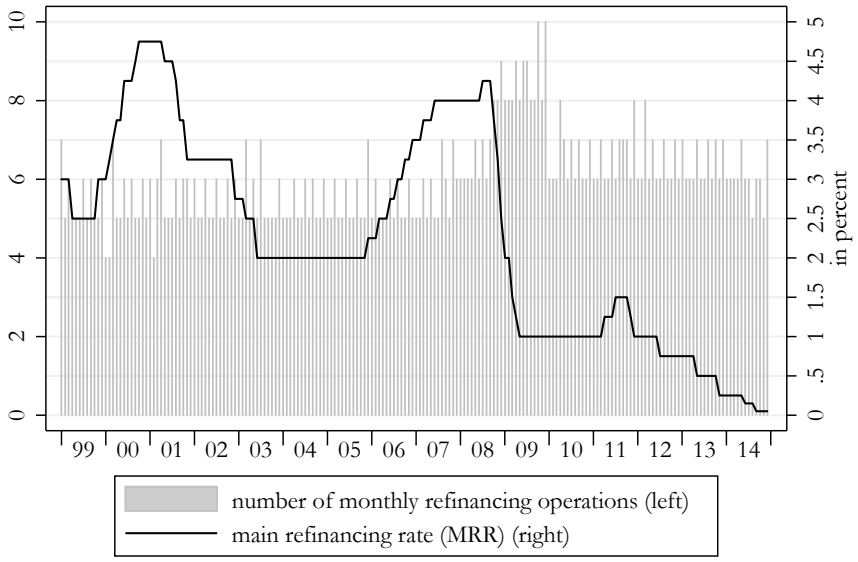
The *amount* was limited by variable-rate tenders without full allotment prior to the financial crisis. Since October 2008, the Eurosystem has performed liquidity provision via fixed-rate tenders with full allotment.[42] The switch to fixed-rate tenders with full allotment was crucial for the substantial expansion of liquidity provision as it implies that the Eurosystem determines the interest rate and eligible counterparties can borrow without limit at the given rate of interest. Moreover, the Eurosystem markedly increased the number of refinancing operations since 2008,

[41] Longer maturities of provided liquidity endorsed banks to alleviate maturity mismatch between the investment side and the funding side of their balance sheets (ECB 2010d).

[42] The Eurosystem applied fixed-rate tenders (without full allotment) at the very beginning of the third stage of the European Monetary Union (EMU) (January 1999 to June 2000). In relation to Figure 2.6, this implies that the depicted interest rate corresponds to the fixed MRR from January 1999 to June 2000 and from October 2008 to December 2014, while it is the marginal MRR from June 2000 to October 2008. See also Vergote et al. 2010.

Figure 2.6: Main refinancing rate and number of refinancing operations

The figure depicts the development of the MRR between 1999 and 2014 on the right scale. The MRR was successively lowered after the onset of the financial crisis, amounting to a historical low of 0.05% at the end of 2014. Moreover, the figure details the number of monthly refinancing operations (left scale). While the Eurosystem conducted 5.5 operations on average per month during pre-crisis times, the average increased to 8.9 between October 2008 and December 2014.



Source: author's calculation; European Central Bank.

as shown in Figure 2.6. While the Eurosystem performed 5.5 refinancing operations per month on average during pre-crisis times, the average increased to 8.9 operations between October 2008 and December 2014. In these operations, the Eurosystem granted refinancing credit to the amount of EUR 87.3 tn (pre-crisis) and EUR 50.7 tn (October 2008 to December 2014). This implies an increase in the average monthly provision of liquidity from EUR 746.5 bn to EUR 889.6 bn.[43] These developments facilitated the availability of liquidity and contributed to its substantial expansion, as is evident in Figure 2.2. With refinancing credit being fully allotted at a higher frequency, liquidity is de facto limited by eligible collateral only (see e.g. Nyborg and Strebulaev 2001).

The Eurosystem took a multitude of actions to prevent any potential limitation of eligible collateral, i.e. to ensure *collateral* availability in the Eurozone and more particularly in certain crisis-stricken countries. The collateral framework and its development is described and analyzed in depth in Chapter 3. Moreover, the chapter investigates the development of eligible marketable assets (collateral pool) and how it was affected by amendments to collateral criteria. The use of eligible collateral is analyzed in Chapter 5. Amendments to collateral criteria kept sufficient eligible marketable assets available, as Figure 1.1 indicates.

The *haircut* is the sixth determinant of credit terms. Haircuts are closely connected to collateral in the Eurozone for two reasons. On the one hand, both collateral criteria and haircuts are laid down in the collateral framework of the Eurosystem. On the other hand, collateral and haircuts constitute risk mitigation in liquidity provision, which takes place in two steps: first, collateral

[43] However, the average number of bidders per transaction decreased from 375 to 154. The information is provided on the homepage of the ECB.

is taken as protection against the risk of counterparty default; and second, haircuts are applied to discount the value of collateral assets as hedge against collateral-related risk. Haircuts are identified as the key risk control measure of the Eurosystem in Chapter 4, where the general principles of haircut determination and the development of Eurosystem haircuts are elaborated in depth.

2.4 The Growing Importance of the Eurosystem Collateral Framework

Central bank collateral frameworks in general and the framework of the Eurosystem in specific has gained increasing importance over the last decade. Their basic function is to define the set of assets eligible for liquidity provision by central banks (in terms of both loans and asset purchases). Furthermore, collateral frameworks determine the quantity of liquidity that counterparties can draw from central banks in exchange for collateral assets by laying down the rules for asset valuation. According to Nyborg 2015, this places central bank collateral frameworks at the core of the monetary and financial system, and it renders them "one of the most complex and economically significant elements of monetary policy implementation" (Bindseil 2013, p. 5).

The observable growing *general importance* of central bank collateral frameworks is based on the two opposing effects of amendments to collateral criteria (see Chapter 1). Collateral is the primary means of risk mitigation in central bank liquidity provision. Hence, relaxation of collateral criteria implies a trade-off between ensuring liquidity access of counterparties, which facilitates the implementation of monetary policy and the assumption of additional credit risk (Chailloux et al. 2008b). Central banks oppose potential collateral scarcity by relaxing collateral criteria to reshape the market perception of high-quality assets (Levels and Capel 2012, BIS 2013a). The importance of collateral criteria for market perception is reinforced by Singh 2013, who defines the post-Lehman period as a "new collateral space" in which activity of additional market participants such as central banks influenced collateral availability. Collateral availability is particularly important when interest rates approach the zero-lower bound and central banks strive to extend liquidity provision. In this case, collateral availability is the de facto constraint to liquidity provision. However, extended liquidity provision is associated with credit risk, which is best mitigated by lending only against "good collateral".[44] Relaxing collateral criteria to free up additional yet lower-quality collateral amplifies credit risk. Furthermore, Nyborg 2015 emphasizes the growing importance of central bank collateral criteria as they shape conditions in the market for liquidity, which spill over to financial markets.

The *specific importance* of the Eurosystem collateral framework is revealed by its key role in the extension of liquidity provision in the Eurozone.[45] The General Documentation of the Eurosystem stipulates that any liquidity-providing OMO should be based on assets that are compliant with the collateral framework (ECB 2015b). Accordingly, it prescribes that only eligible marketable assets as specified by the collateral framework qualify for being purchased by

[44] "Good collateral" in terms of Bagehot 1873. See Goodhart 1999 and Tucker 2009. For the role of collateral in central bank risk protection, see also Stone et al. 2011.

[45] Nyborg 2015 attributes an integral part of the Eurosystem's fight to save the euro to the collateral framework.

the Eurosystem, thus rendering the collateral framework the guiding principle for the numerous asset purchase programs.[46] The importance of the collateral framework for lending is grounded in the Statute of the ESCB and of the ECB, with Article 18.1 requiring that Eurosystem credit operations are based on adequate collateral (ECB 2012e and Chapter 1). Hence, the relaxation of collateral criteria has been crucial to the Eurosystem in terms of performing its standard and non-standard measures of monetary policy in recent years.[47] It served as a major means of crisis mitigation as freed-up assets were considered eligible for both asset purchases and collateralized loans. Moreover, it was key to the accumulation of intra-Eurosystem imbalances (see Section 7.3.3) and ELA, which is provided to illiquid yet solvent banks against collateral not complying with the uniform criteria (see Section 7.3.2).

Therefore, the importance of the Eurosystem collateral framework has been fostered over recent years when the Eurosystem relaxed it to substantially extend liquidity provision. The growing importance was initially disregarded,[48] although it has been more recently widely acknowledged and emphasized by e.g. Sinn 2012, Cour-Thimann and Winkler 2013, Eberl and Weber 2013, ECB 2013c, Cassola and Koulischer 2014, Eberl and Weber 2014a,b, Claeys 2014, Claeys et al. 2014, Drechsler et al. 2015, Wolff 2014, Sinn 2014a,b, Belke 2015, Eberl and Weber 2015, ECB 2015c, Fecht et al. 2015 and Sinn 2015b. The Eurosystem collateral framework is comprehensively addressed in the next chapter, as well as reflecting the central topic of the remainder of this dissertation.

[46] Note that this likely does not hold for government bond purchases under the ANFA for which purchase criteria thus far are confidential.

[47] For the evaluation of Eurosystem monetary policy with respect to standard and non-standard measures, see Lenza et al. 2010, ECB 2011e, Cour-Thimann and Winkler 2013 as well as Claeys 2014.

[48] Early pointers concerning the importance of the collateral framework can be found in e.g. ECB 2010d and Sinn 2010b.

3

The Collateral Framework of the Eurosystem[49]

This chapter provides an in-depth analysis of the Eurosystem collateral framework and its effects on the pool of eligible marketable assets ("collateral pool"). It compiles a narrative database of general principles of the collateral framework as well as changes to collateral criteria from 2001 to 2014 in general and by asset type, eliciting information from all relevant official documents released by the Eurosystem.[50] The chapter carves out two effects of the frequent amendments of the collateral framework. On the one hand, they made the collateral framework opaque, which contradicts the Eurosystem's claim for a "simple and transparent" collateral framework (cf. ECB *2007b, p. 87). On the other hand, they facilitated broadening the collateral pool both horizontally (i.e. the Eurosystem deemed eligible additional asset types of given credit quality) and vertically (i.e. the Eurosystem deemed eligible additional assets of lower credit quality). The chapter is structured as follows. Section 3.1 describes the Eurosystem collateral framework in terms of its emergence and general principles. Section 3.2 analyzes the development of collateral criteria concerning the evolution of general collateral criteria and criteria specific to asset types, i.e. debt instruments issued or guaranteed by governments, debt instruments traded on non-regulated markets, covered and uncovered bank bonds, ABSs as well as corporate bonds. Finally, Section 3.3 analyzes the effects of amendments to collateral criteria on the collateral pool along different dimensions, i.e. its geographical composition, its composition by asset type, credit quality, denomination and residual maturity. Moreover, the effects of extended eligibility of government guarantees and securities traded on non-regulated markets for the development of the collateral pool are scrutinized.*

[49] Sections 3.1 and 3.2 base on Eberl and Weber 2014a and Section 3.3 on Eberl and Weber 2015.

[50] The majority of information originates from official documents of the Eurosystem. In particular, this includes official documents of the General and Temporary Framework as well as press releases. Additional information was provided to the author by the Eligible Assets Team in bilateral communication.

3.1 Collateral Criteria of the Eurosystem[51]

As discussed in Section 2.4, Article 18.1 of the Statute of the ESCB and the ECB allows the Eurosystem to operate in financial markets based on "adequate collateral". The Eurosystem ensures adequacy of collateral through its collateral framework. Accordingly, this section examines the framework in terms of its initial design, the "Single List" of eligible assets, the distinction between general and temporary collateral criteria and its general principles.

3.1.1 The Initial Collateral Framework: Tier 1 and Tier 2 Eligibility

The Eurosystem initially (i.e. in 2001) distinguished between two classes of eligible assets, namely tier 1 and tier 2 assets. Various types of marketable and non-marketable assets were initially deemed and made eligible over time within the two classes. Marketable assets are assets for which active markets exist and which may be liquidated in a short time, such as government bonds, bank bonds and corporate bonds.[52] Hence, these assets typically feature a market value. By contrast, non-marketable assets are not traded on a regular market; rather, they are dealt in private transactions or held by the owner to maturity.[53] Consequently, they generally lack a market value. In particular, the type of asset, the type and residence of the issuer/debtor/guarantor, the place of issuance, the credit quality of the asset and its denomination are crucial elements for eligibility and thus they were subject to alteration.

The initial distinction between tier 1 and tier 2 assets was considered necessary as economic integration across the Eurozone was in its early stages and differences in financial structures remained substantial. Therefore, NCBs were given the right to consider eligible for tier 2 certain assets regarded as particularly important for national financial markets and banking systems. Uniform criteria were only applied to tier 1 assets, permitting two types of assets: debt certificates issued by the ECB or NCBs prior to the adoption of the euro and debt instruments issued or guaranteed by entities established in the EEA that were admitted to trading on regulated and non-regulated markets (see also Section 3.2.3).[54] Moreover, tier 1 assets had to meet "high credit standards" to ensure the financial soundness of the pledging counterparty (ECB 2000). These standards were not further specified at the beginning. Furthermore, debt instruments had to be denominated in euro and NCBs were prohibited to accept as collateral "own-use debt instruments", i.e. debt instruments pledged by the issuing counterparty itself. Collateral criteria for tier 2 assets were not uniform but rather established idiosyncratically by NCBs and subject

[51] See e.g. ECB 2011f and Deutsche Bundesbank 2015 for further details on the role of collateral in monetary policy of the Eurosystem.

[52] At the end of 2014, the set of eligible marketable assets comprised ECB debt certificates, central government debt instruments, debt instruments issued by central banks, local and regional government debt instruments, supranational debt instruments, covered bank bonds, credit institutions debt instruments, debt instruments issued by corporate and other issuers and ABSs. The ECB publishes a daily list of eligible marketable assets on ISIN-basis.

[53] At the end of 2014, the set of eligible non-marketable assets comprised credit claims/bank loans, retail mortgage-backed debt instruments (RMBDs) and fixed-term deposits. Credit claims are defined as the debt obligations of a debtor vis-à-vis a Eurosystem counterparty. RMBDs are debt instruments (promissory notes or bills of exchange) that are secured by a pool of retail mortgages but fall short of full securitization. Only Irish mortgage-backed promissory notes have been labeled as RMBDs. Due to non-marketability, the Eurosystem does not provide information on the amount of eligible non-marketable assets.

[54] These entities included Eurosystem, public sector and private sector entities from EEA countries as well as international and supranational institutions.

to approval by the ECB Governing Council. Tier 2 assets had to be either debt instruments (marketable and non-marketable) or equities traded on regulated markets.[55] Tier 2 assets also had to be denominated in euro and were ineligible if they were own-use.

3.1.2 A Comprehensive Collateral Framework: the Single List

As economic and financial integration proceeded, the ECB repealed the possibility of the idiosyncratic acceptance of assets by NCBs and introduced the Single List as a comprehensive framework for eligible assets in January 2007.[56] The two-tier system was phased out such that tier 2 assets not qualifying for the Single List remained eligible until 31 May 2007.[57] The Single List has drawn a distinction between marketable and non-marketable assets. While marketable assets comprised former tier 1 assets, two types of assets were initially summarized as non-marketables: credit claims, i.e. bank loans, and RMBDs. The ECB thereby harmonized the former idiosyncratic criteria for tier 2 assets, with the exception of credit claims for which certain idiosyncratic acceptance criteria remained in place.[58]

3.1.3 Two Parallel Collateral Frameworks

At the end of 2014, collateral criteria were specified in two parallel frameworks established by the Eurosystem: *(i)* the General Framework and *(ii)* the Temporary Framework. Whenever assets comply with the eligibility criteria, NCBs are in principal obliged to accept assets as collateral. General collateral criteria in terms of the General Framework are defined in the General Documentation (see ECB 2015b). Furthermore, the Temporary Framework complements the General Framework and lays down additional temporary collateral criteria that were deemed necessary when financial markets entered turmoil and the full allotment of refinancing credit via fixed-rate tenders called for additional collateral. This Temporary Framework can be adapted to local needs upon the condition that certain minimum risk control requirements are met (see ECB 2015c). Hence, the Eurosystem brought the Temporary Framework into being in October 2008, which was initially intended to expire at the end of 2009. However, as liquidity demand

[55] Moreover, the ECB could authorize NCBs to include other assets, e.g. debt instruments issued by credit institutions not complying with Article 22.4 of Directive 88/220/EEC amending Directive 85/611/EEC (hereafter referred to as "Undertakings for Collective Investment in Transferable Securities (UCITS) Directive"). According to the ECB, a credit institution is either *(i)* an undertaking whose business is to receive deposits or other repayable funds from the public and grant credit for its own account or *(ii)* an undertaking or any other legal person, other than those under (i), which issues means of payment in the form of electronic money. For the sake of simplicity, credit institutions are hereafter referred to as banks. Article 22.4 of the UCITS Directive specifies the following requirements: *(i)* the issuer of the bond must be a credit institution; *(ii)* the issuance has to be governed by a special legal framework; *(iii)* the issuing institutions must be subject to special prudential public supervision; *(iv)* the set of eligible assets to cover the bond must be defined by law; *(v)* the cover asset pool must provide sufficient collateral to cover bondholder claims throughout the whole lifetime of the covered bond; and *(vi)* bondholders must have priority claim on the cover asset pool in case of the issuer's default. Covered bonds complying with the requirements are considered particularly safe and will be denoted as "UCITS-compliant covered bank bonds" or simply as "covered bank bonds" in the following.

[56] See e.g. ECB 2006c for a description of the Single List.

[57] Units of French fonds communs de créancess (FCCs; French securization funds) that were previously eligible as tier 1 remained eligible until 31 December 2008.

[58] The Single List allowed for idiosyncratic criteria regarding the minimum threshold for the size of credit claims and charging a handling fee until December 2011. Thereafter, NCBs were allowed to idiosyncratically accept credit claims within the additional credit claims (ACCs) framework, see Section 3.2.1.2.

further grew, rather than returning to normal, it was maintained to complement the General Framework.

As a result, having initially been designed as a "crisis framework", established for a limited period and intended to provide additional collateral to facilitate the temporary extension of liquidity provision, the Temporary Framework turned into a long-lasting framework that remained in force at the end of 2014. Important collateral criteria that were initially envisaged to be temporary were assumed in the General Framework or in force without an expiration date.

3.1.4 General Principles of the Collateral Framework

Three general principles of the Eurosystem collateral framework are discussed hereafter: *(i)* close links between counterparties; *(ii)* principles for assessing the value of eligible assets; and *(iii)* the European Credit Assessment Framework (ECAF), according to which the credit quality of eligible assets is appraised.

3.1.4.1 Close Links

The ineligibility of assets with close links was already part of the initial General Framework in 2001. Accordingly, assets were deemed ineligible if issued by the counterparty itself or any other closely related entity. The most extreme case of close links is the own use of assets, whereby the asset is issued and pledged by the same party. Close links were initially defined according to Directive *2000/12/EC* of the EC, focusing on links in participation or control (see EC 2000).[59] Four exceptions were made with respect to *(i)* close links between the pledging counterparty and public authorities of EEA countries; *(ii)* close links in trade bills, i.e. trade bills for which at least one entity (other than a credit institution) was liable in addition to the pledging counterparty; *(iii)* close links in UCITS-compliant covered bank bonds; and *(iv)* cases in which debt instruments were protected by specific legal safeguards comparable to *(iii)*, which were not further specified.

The definition of close links and collateral criteria applied to assets were successively altered, as shown in Table 3.1.[60] In May 2005, the Eurosystem deviated from the EC's general definition of close links, matching the definition to its collateral framework.[61] The definition was slightly

[59] According to Directive *2000/12/EC*, the Eurosystem defined close links as situations in which two or more entities were linked by *(i) participation*, which meant "the ownership, direct or by way of control, of 20% or more of the voting rights or capital of an undertaking", or *(ii) control*, which meant "the relationship between a parent undertaking and a subsidiary, in all the cases referred to in Article 1.1 and 1.2 of Directive *83/349/EEC*, or a similar relationship between any natural or legal person and an undertaking; any subsidiary undertaking of a subsidiary undertaking shall also be considered a subsidiary of the parent undertaking which is at the head of those undertakings." Furthermore, a situation in which two or more entities were "permanently linked to one and the same person by a control relationship shall also be regarded as constituting a close link between such persons," see EC 2000 in conjunction with EEC 1983. The EC emphasizes that this definition only laid down minimum criteria for the provision of close links.

[60] The table also includes developments specific to asset types. For the description of these specific applications of close links, see the respective sections below.

[61] As of May 2005, the Eurosystem defines close links as situations in which *(i)* "the counterparty owns 20% or more of the capital of the issuer, or one or more undertakings in which the counterparty owns the majority of the capital own 20% or more of the capital of the issuer, or the counterparty and one or more undertakings in which the counterparty owns the majority of the capital together own 20% or more of the capital of the issuer;" or *(ii)* "the issuer owns 20% or more of the capital of the counterparty, or one or more undertakings in

changed in January 2007 when the close links provision became not only relevant to issuers but also to debtors and guarantors. At the same time, trade bills with close links were deemed ineligible. The ECB made a significant change in February 2009, which is also addressed in Section 3.2.2 and Chapter 8. As government guarantees gained importance with the onset of the financial crisis, the Eurosystem deemed government-guaranteed debt instruments with close links eligible. Hence, marketable and non-marketable debt instruments with close links were deemed eligible (including own-use), provided that they were guaranteed by a government of an EEA country and complied with the general collateral criteria. Furthermore, RMBDs with close links likewise became eligible.

3.1.4.2 Valuation Principles

Valuation principles lay down rules concerning how to assess the value of assets pledged as collateral. These principles hold crucial importance since the Eurosystem applies its risk control measures based on this valuation.[62] Valuation principles were already broadly specified in the initial collateral framework, before being successively altered over time. At the end of 2014, the Eurosystem assessed the value of a marketable asset based on either its market price or a theoretical value. First, the market price on the business day preceding the valuation date is considered. If more than one price is quoted, the lowest of these prices is used. In the absence of a price on the preceding business day, the last trading price is adduced. If the last available price is older than (or has not moved for at least) five days, the Eurosystem assigns a theoretical value to the asset. Valuation markdowns are applied when the value is not supported by a market price for covered and uncovered bank bonds as well as ABSs.[63] For non-marketable assets, a theoretical value or the outstanding amount is used.

Hence, the Eurosystem implemented cautious principles regarding the valuation of eligible assets, although potential valuation errors cannot be fully ruled out. Indeed, this holds for both marketable and non-marketable assets and is particularly relevant for own-use assets that are not traded. The absence of a market price requires theoretical valuation, which is prone to valuation errors. In case of overvalued assets, the liquidity provided would be too high. Furthermore, risk control measures (e.g. the haircut) applied to an overvalued asset would not fully hedge the underlying risk and in case of default the pledged security might be insufficient to cover outstanding claims.[64,65]

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which the issuer owns the majority of the capital own 20% or more of the capital of the counterparty, or the issuer and one or more undertakings in which the issuer owns the majority of the capital together own 20% or more of the capital of the counterparty;" or *(iii)* "a third party owns both the majority of the capital of the counterparty and the majority of the capital of the issuer, either directly or indirectly, through one or more undertakings in which that third party owns the majority of the capital," (see ECB 2005, p. 35).

[62] See Chapter 4 for Eurosystem risk control.

[63] Valuation markdowns are deductions directly applied to the theoretical value prior to the application of further risk control measures, see Section 4.1.

[64] The haircut reflects the difference between the value that the Eurosystem assigns to an eligible asset and the amount of the loan, see Section 4.1.

[65] Imagine that the true value of an asset that a bank pledges with the Eurosystem is 80 but unknown to the Eurosystem. Moreover, the Eurosystem cannot consult the market price, e.g. because the asset is not traded. Due to the lack of information, the Eurosystem may overvalue the asset and assign a theoretical value of e.g. 100. For every haircut less than 20%, the Eurosystem would grant refinancing credit that is not entirely collateralized. For a haircut of e.g. 10%, the Eurosystem would be left with a loss of 10 in case of bank default.

Table 3.1: Changes to the collateral criteria of securities with close links

The table depicts the evolution of collateral criteria of securities with close links from 2001 to 2014. The most extreme case of close links is the own use of assets, whereby the asset is issued and pledged by the same party. Initial criteria were broadly defined and seldom changed prior to the onset of the financial crisis. Thereafter, amendments became more frequent and related to specific asset types (especially bank bonds).

Date	Action	Asset Type
01/01/2001	Ineligibility of debt instruments with close links (with exceptions); definition of close links according to Directive 2000/12/EC (ECB/2000/7)	all
30/05/2005	Modification of the definition of close links beyond Directive 2000/12/EC (ECB/2005/2)	all
01/01/2007	Ineligibility of trade bills with close links (ECB/2006/12)	trade bills
01/02/2009	Eligibility of government-guaranteed debt instruments and of RMBDs with close links; ineligibility of ABSs with close links within a currency hedge (ECB/2008/13)	all, RMBDs, ABSs
10/10/2010	Eligibility of residential real estate loan-backed structured covered bank bonds with close links (ECB/2010/13)	covered bank bonds (ABSs)
01/02/2011	Eligibility of commercial mortgage loan-backed structured covered bank bonds with close links (ECB/2010/30)	covered bank bonds (ABSs)
19/12/2011	Ineligibility of ABSs with close links within an interest rate hedge (ECB/2011/25, ECB/2012/11, ECB/2012/17, ECB/2012/18, ECB/2013/4)	ABSs
03/07/2012 to 02/05/2013	Limitation of use of government-guaranteed bank bonds with close links (ECB/2012/12, ECB/2011/25, ECB/2012/17, ECB/2012/18)	bank bonds
03/01/2013	Eligibility of further non-UCITS-compliant covered bank bonds with close links (ECB/2012/25)	covered bank bonds
03/05/2013 to 28/02/2015	Release of NCBs obligation to accept eligible government-guaranteed uncovered bank bonds with close links where the guarantor is a country under an EU/IMF program and whose credit assessment does not meet high credit standards; limitation of the use of government-guaranteed uncovered bank bonds with close links (ECB/2013/4)	uncovered bank bonds
01/03/2015	Ineligibility of government-guaranteed uncovered bank bonds with close links (ECB/2013/6)	uncovered bank bonds

Source: author's compilation.

3.1.4.3 The European Credit Assessment Framework (ECAF)

Since January 2007, the Eurosystem has pursued the objective that eligible assets comply with uniform credit rating standards by establishing the ECAF.[66] The ECAF was introduced to determine the creditworthiness of assets based on information provided by different credit assessment sources.[67] The Eurosystem stipulated in its initial General Framework that at least one credit assessment from an eligible ECAI for the issued security *(issue)* had to comply with "high credit standards". The ECB specified in January 2007 that in the absence of a rating for the issue, the creditworthiness of the *issuer* would be decisive. In case of a guaranteed issue, the creditworthiness of the *guarantor* was considered in third place. Thereby, the Eurosystem established a pecking order of credit ratings that takes into account the *(1)* issue, *(2)* issuer and *(3)* guarantor in determining eligibility. The respective next credit rating was only used when the precedent rating was not available. The Eurosystem defined down the pecking order in October 2013 when it decided that *program* ratings could be considered equal to issue ratings.[68] Moreover, credit ratings of the issuer or guarantor have been taken equally into account according to a first-best rule in the absence of an issue or program rating. Hence, the Eurosystem extended the first step and equated the second and third steps of the pecking order. A first-best rule has already been applied since January 2007, when issue ratings from eligible ECAIs differ.[69]

The Eurosystem undertook a major step towards making ratings from different ECAIs comparable in January 2011 when it introduced its "harmonized rating scale". At the end of 2014, the Eurosystem took into account credit ratings from four rating agencies: Standard & Poor's (S&P), Moody's, Fitch and Dominion Bond Rating Service (DBRS). As ECAIs assess credit risk according to different rating scales, the harmonized rating scale aimed at standardizing the divergent scales.[70] The Eurosystem defined three credit quality steps (CQSs) for short- and long-term credit assessments, as illustrated in Table 3.2.[71] Since October 2013, the Eurosystem has distinguished short- (i.e. assets with an original maturity of up to 390 days) from long-term assets (i.e. assets with an original maturity of more than 390 days). For the former, both short-

[66] Uniform credit rating standards are fundamental as risk control is performed based on the credit rating assigned to assets. See Chapter 4 as well as Brendel et al. 2015 and ECB 2015c.

[67] More specifically, the ECAF relies on four credit assessment sources: *(i)* External Credit Assessment Institutions (ECAIs), *(ii)* NCBs' in-house credit assessment systems, *(iii)* counterparties' internal ratings-based systems and *(iv)* third-party providers' rating tools. As ECAIs cover all eligible issuers/debtors/guarantors from EEA or non-EEA G10 countries, they play the most important role, particularly for the assessment of marketable assets (see ibid.). *(ii)* and *(iv)* cover only country-specific non-financial corporations, while the use of *(iii)* has to be approved by NCBs and is subject to performance monitoring. Hence, credit rating requirements are generally defined in terms of ECAIs ratings.

[68] See Brendel et al. 2015 for further information and observed obscurities in the implementation of the redefined pecking order by NCBs.

[69] For ABSs, the Eurosystem set up the second-best rule in October 2010, according to which the second-best available credit rating also had to comply with the minimum rating threshold for ABSs.

[70] The S&P long-term rating scale comprises 22 credit rating notches from AAA to D, while the scale of Moody's comprises 21 (Aaa to C), the scale of Fitch 20 (AAA to D) and DBRS differentiates between 26 notches (AAA to D).

[71] Table 3.2 shows that the three CQSs are defined as follows: CQS 1 ranges from a long-term rating of "triple A" (Eurosystem's notation) equal to "Aaa" from Moody's and "AAA" from Fitch, S&P and DBRS to a rating of "Aa3" from Moody's and "AA-" from Fitch and S&P as well as "AAL" from DBRS. CQS 2 equals at least "single A" (Eurosystem), which means a rating of "A-" by Fitch or S&P, "A3" by Moody's or "AL" from DBRS. This is deemed equivalent to a probability of default (PD) over a one-year horizon of 0.1%. Finally, CQS 3 corresponds to a credit rating of at least "triple B" (Eurosystem), which is equal to "BBB-" from Fitch or S&P, "Baa3" from Moody's and "BBBL" from DBRS. CQS 3 is considered equivalent to a PD of 0.4% over a one-year horizon. For convenience, the notation of the Eurosystem is used in the following whenever possible.

and long-term ratings are considered on a first-best rule basis. For the latter, only long-term ratings are used.

Table 3.2: Harmonized rating scale of the Eurosystem

The table displays the harmonized rating scale according to which credit ratings of the four agencies are matched. Three ratings of DBRS are highlighted as they were belatedly shifted (Brendel et al. 2015). The long-term rating BBBL was introduced in CQS 3 in April 2014. The short-term rating R-1L was moved from CQS 1/2 to 3 and R-2L was introduced to CQS 3 in 2014. Hence, the Eurosystem relaxed collateral criteria by deeming eligible assets with a first-best rating of BBBL or R-2L from DBRS.

		Credit Quality Step (CQS)		
		1	2	3
Short-Term	DBRS		R-1H, R-1M	**R-1L**, R-2H, R-2M, **R-2L**
	Fitch		F1+, F1	F2
	Moody's		P-1	P-2
	S&P's		A-1+, A-1	A-2
Long-Term	DBRS	AAA to AAL	AH to AL	BBBH to **BBBL**
	Fitch	AAA to AA-	A+ to A-	BBB+ to BBB-
	Moody's	Aaa to Aa3	A1 to A3	Baa1 to Baa3
	S&P's	AAA to AA-	A+ to A-	BBB+ to BBB-

Source: author's illustration; European Central Bank; see also Brendel et al. 2015.

3.2 Development of Collateral Criteria of the Eurosystem

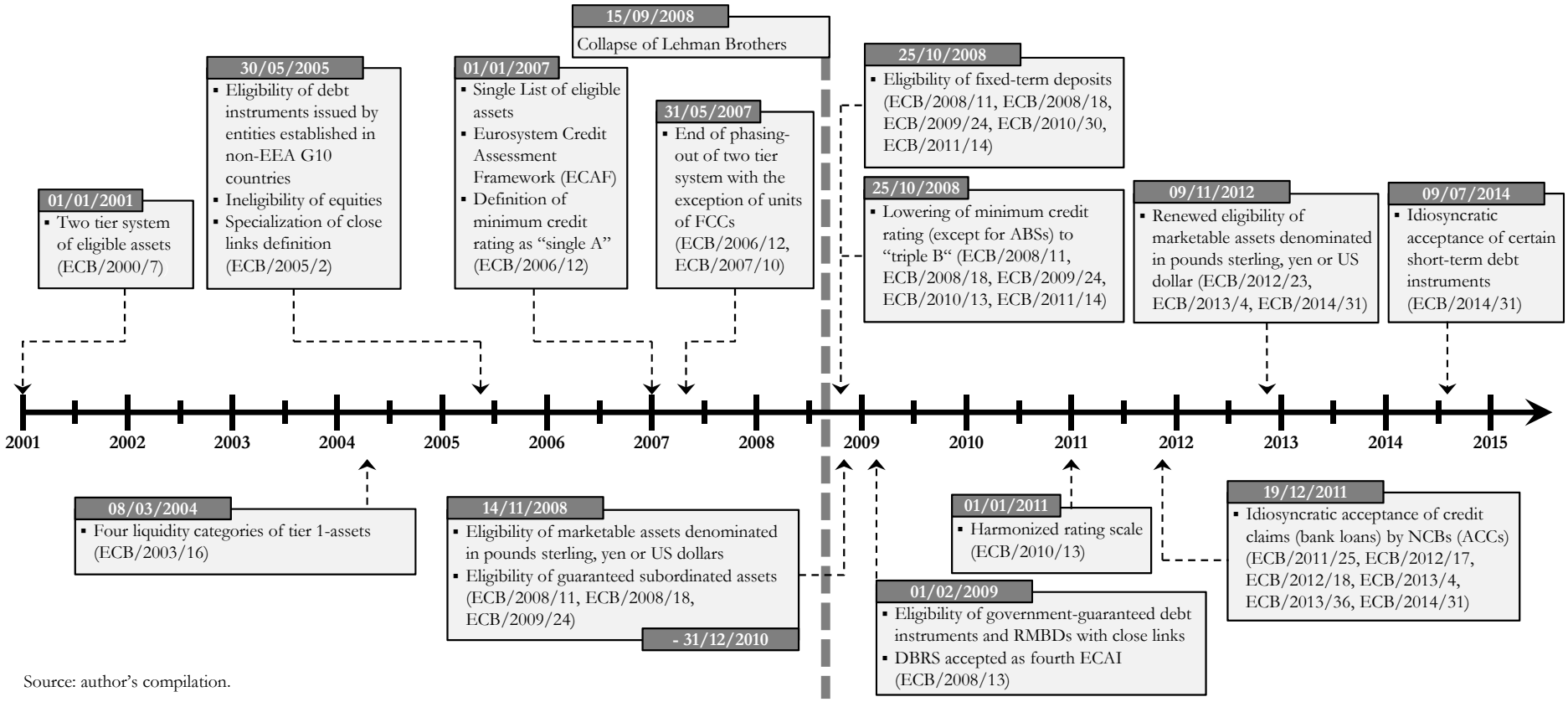
Having described the initial collateral framework and its general principles, this section elaborates on the development of the collateral framework. It starts by discussing general changes affecting the eligibility of marketable and non-marketable assets. This discussion is followed by a description of the amendments to collateral criteria of bonds issued or guaranteed by governments and debt instruments traded on non-regulated markets. Finally, changes to the collateral criteria of three asset types are investigated, namely bank bonds, ABSs and corporate bonds.

3.2.1 Changes to General Collateral Criteria

Modifications to the collateral criteria applied to marketable and non-marketable assets were manifold and are arranged in Figure 3.1. The timeline shows that the Eurosystem's activity in modifying general collateral criteria has amplified over time. In the first years after setting up its collateral framework (2001-2007), the Eurosystem made only a few modifications aimed at standardizing and harmonizing the framework. Idiosyncratic collateral criteria were scrapped and no amendments were made in response to market developments. Nonetheless, since the onset of the financial crisis in the fall of 2008, the Eurosystem has intensified amendments to the collateral framework to alleviate turmoil in financial markets.

Figure 3.1: Changes to general collateral criteria

The timeline depicts the amendments to general collateral criteria from 2001 to 2014. The Eurosystem made only few modifications aimed at standardizing and harmonizing the framework during the first years (2001-2007). During that time, idiosyncratic collateral criteria were abolished and no amendments were made in response to market developments. The Eurosystem intensified amendments since the onset of the financial crisis in the fall of 2008 in response to financial market turmoil.



Source: author's compilation.

3.2.1.1 Standardization and Harmonization of the Collateral Framework (2001-2007)

The Eurosystem made first amendments to the collateral framework in March 2004 when marketable assets were divided into four categories of decreasing liquidity, i.e. liquidity categories (LCs).[72] Moreover, the nature of a guarantee for eligible tier 1 and tier 2 assets was further specified.[73]

Euro-denominated debt instruments issued by entities established in countries that were part of the G10 but not the EEA, i.e. the US, Canada, Japan and Switzerland, became eligible as of May 2005. In contrast to this relaxation of collateral criteria, equities were deemed ineligible. Furthermore, the Eurosystem made first efforts towards the Single List (see Section 3.1.2) by announcing that it would phase out the two-tier system and replace it with a uniform framework of marketable and non-marketable assets. The Single List was subsequently introduced in January 2007 as the most substantial step towards standardizing and harmonizing the collateral framework.

3.2.1.2 Modification of the Collateral Framework in Response to the Crises (2008-2014)

The endeavor of the Eurosystem to create a coherent collateral framework was interrupted by the collapse of Lehman Brothers in September 2008. As a prompt response to turmoil in financial markets, the Eurosystem made one of the most fundamental changes to its collateral framework in October 2008 by lowering the minimum credit rating threshold for eligible assets (except for ABSs) from "single A" to "triple B", i.e. right above junk status. In order to capture additional risk involved in the acceptance of low-quality assets, the Eurosystem applied a uniform add-on haircut to assets with a rating lower than "single A", i.e. to assets later summarized in CQS 3. Whereas the lowering was initially intended to be temporary, it was prolonged by several legal acts until January 2011. Accordingly, it was adopted in the General Framework and hence it remains in force without an expiration date.[74]

The Eurosystem initially collected fixed-term deposits for fine-tuning purposes only, i.e. to steer market liquidity. This became particularly relevant after the Eurosystem started asset purchases in July 2009 (see Section 2.2). Nevertheless, the Eurosystem already allowed counterparties to pledge fixed-term deposits as collateral as of October 2008. As eligibility was only temporarily valid, it had to be prolonged twice (in December 2008 and January 2010). Since January 2011, fixed-term deposits have been included in the General Framework as a third type of eligible non-marketable assets.

[72] Central government debt instruments and debt instruments issued by central banks were subsumed in LC 1. Local and regional government debt instruments as well as jumbo Pfandbrief-style debt instruments, agency debt instruments and supranational debt instruments were summarized as LC 2. All traditional Pfandbrief-style debt instruments, credit institution debt instruments and debt instruments issued by corporate and other issuers were marked as LC 3, while all eligible ABSs were classified as LC 4.

[73] From then onwards, a guarantee has been accepted if the guarantor had unconditionally and irrevocably guaranteed the obligation with respect to the payment of principal, interest and any other amounts. The guarantee was to be payable on first demand but not necessarily in the case in which the guarantor was a government. Moreover, the obligations of the guarantor had to rank at least equally with unsecured obligations of the guarantor.

[74] The initial legal act came into force on 25 October 2008 and expired on 30 November 2008. The first prolongation lasted from 1 December 2008 until 31 December 2009, while the follow-up prolongation was valid between 1 January 2010 and 31 December 2010.

As another immediate response to the onset of the financial crisis, the Eurosystem deemed temporarily eligible guaranteed subordinated assets together with debt instruments denominated in pounds sterling, yen or US dollars as of November 2008. This was undertaken under the provision that the foreign currency debt instruments were issued and settled in the Eurozone and that the issuer was established in the EEA. Temporary acceptance was again repeatedly prolonged until December 2010.[75] The eligibility of debt instruments denominated in pounds sterling, yen or US dollars was reintroduced in November 2012 and remained in place at the end of 2014.

In February 2009, the Eurosystem undertook an amendment that appears minor upon first glance yet actually holds great significance in practice, whereby the list of accepted ECAIs was expanded to include DBRS as the fourth agency.[76] The inclusion of another ECAI should be advantageous as additional information can be taken into account in the assessment of collateral quality. However, as the first-best rule is applied to eligible assets other than ABSs in case of divergent credit ratings (see Section 3.1.4.3), each ECAI has the power to be pivotal, i.e. it exerts influence on whether assets are *(i)* eligible or *(ii)* subject to lower haircuts applied in CQS 1/2 or to higher haircuts in CQS 3. With each additional ECAI, the competition among rating agencies to provide the pivotal rating increases. Figure 3.2 depicts the development of long-term credit ratings of the governments of Ireland, Portugal, Italy and Spain, as assessed by the four ECAIs. DBRS temporarily provided the best credit rating to these countries and hence was pivotal.[77] For Italy (March 2013 to December 2014) and Spain (August 2012 to December 2014), DBRS was the only ECAI rating the governments' creditworthiness in CQS 1/2. From August 2011 to December 2014, DBRS was the only ECAI rating the government of Ireland in CQS 3. The minimum credit rating threshold was waived for bonds issued or guaranteed by the Portuguese government from July 2011 to August 2014 (see following section). Portugal intended to leave the EU/IMF program in early-2014 under the prerequisite that it was able to refinance in the market. The eligibility of Portuguese government bonds as collateral with the Eurosystem was key to this prerequisite but it was not ensured without suspension of the minimum rating threshold because DBRS provided the best rating of BBBL, although this did not comply with CQS 3 prior to April 2014 (cf. Table 3.2). After introducing BBBL to CQS 3 in April 2014, bonds issued or guaranteed by the Portuguese government remained eligible despite revoking the suspension of the minimum rating threshold in August 2014. The effects of these amendments to collateral criteria may have been particularly strong as for government-guaranteed bonds the rating of the guarantor was put to the second step of the pecking order (October 2013), according to which the decisive credit rating was determined (cf. Section 3.1.4.3).[78]

[75] Prolongations were made in December 2008 and January 2010 until December 2010.

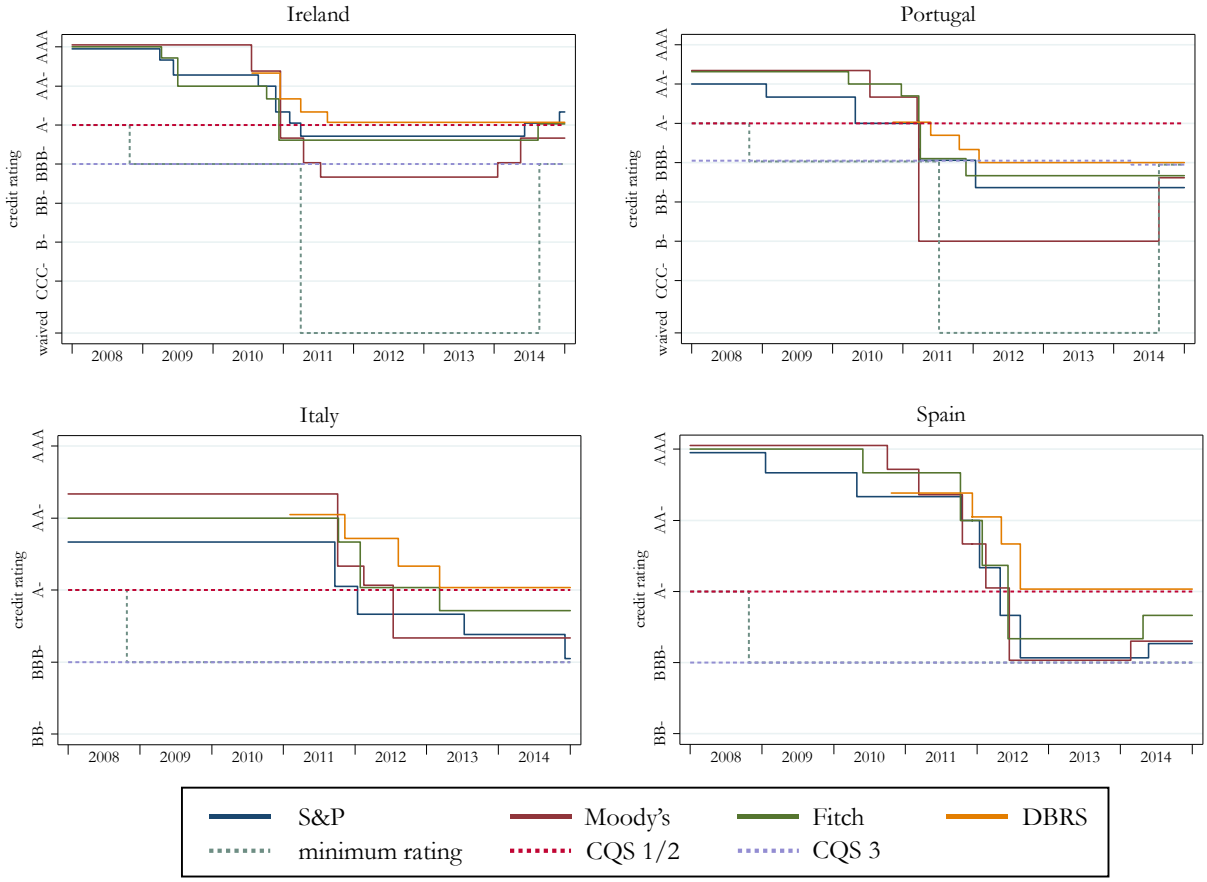
[76] DBRS itself states that it has been an accepted ECAI since 1 January 2008. However, it first appeared as accepted ECAI in a guideline released in October 2008, which entered into force on 1 February 2009 (cf. ECB 2008b). DBRS is a small Canadian agency compared to S&P, Moody's and Fitch, which account for a combined market share of about 95%. It had to close down all its European branches in the aftermath of the financial crisis.

[77] Nyborg 2015 confirms the important role of DBRS, documenting that the first-best rating of DBRS was worth around EUR 200 to 300 bn in increased collateral value. Banks likewise profited from generous credit ratings of DBRS, as described in Brendel et al. 2015.

[78] Moreover, the Eurosystem deemed eligible own-use government-guaranteed debt instruments since February 2009, which coincides with the acceptance of DBRS as ECAI.

Figure 3.2: Long-term government credit ratings for selected countries

The figure details the long-term local currency credit ratings of the governments of Ireland, Portugal, Italy and Spain, as assessed by the four ECAIs. DBRS temporarily provided the best credit rating to these countries. Accordingly, it was pivotal for eligibility of Portuguese government bonds and the assessment of Irish, Spanish and Italian government bonds in CQS 1/2.



Source: author's compilation; European Central Bank; S&P; Moody's; Fitch; DBRS.

The Eurosystem gave NCBs room to idiosyncratically adapt collateral criteria for credit claims to local needs under the so-called ACCs framework in December 2011.[79] NCBs were conferred the right to set up own collateral criteria and risk control measures for credit claims, which subsequently had to be approved by the ECB Council. However, potential losses on pledged credit claims under the ACCs framework were not mutualized but rather borne by the respective NCB.[80] Seven NCBs (Central Bank of Ireland, Banco de España, Banque de France, Banca d'Italia, Central Bank of Cyprus, Oesterreichische Nationalbank and Banco de Portugal) put forward such national collateral criteria. Moreover, as of January 2014, NCBs have been allowed to accept credit claims that are included in a pool of other credit claims or backed by real estate assets in case of exceptional circumstances. Further room for the idiosyncratic acceptance of collateral was conceded to NCBs in July 2014 when they were allowed to deem eligible short-

[79] See Tamura and Tabakis 2013 for a comparison of collateral criteria for credit claims applied by NCBs, as well as further information on the role of credit claims as collateral in recent years.

[80] See Nagel 2012. According to Guideline *ECB/2012/18*, NCBs were only allowed to provide assistance to each other when bilaterally agreed and approved by the ECB Council.

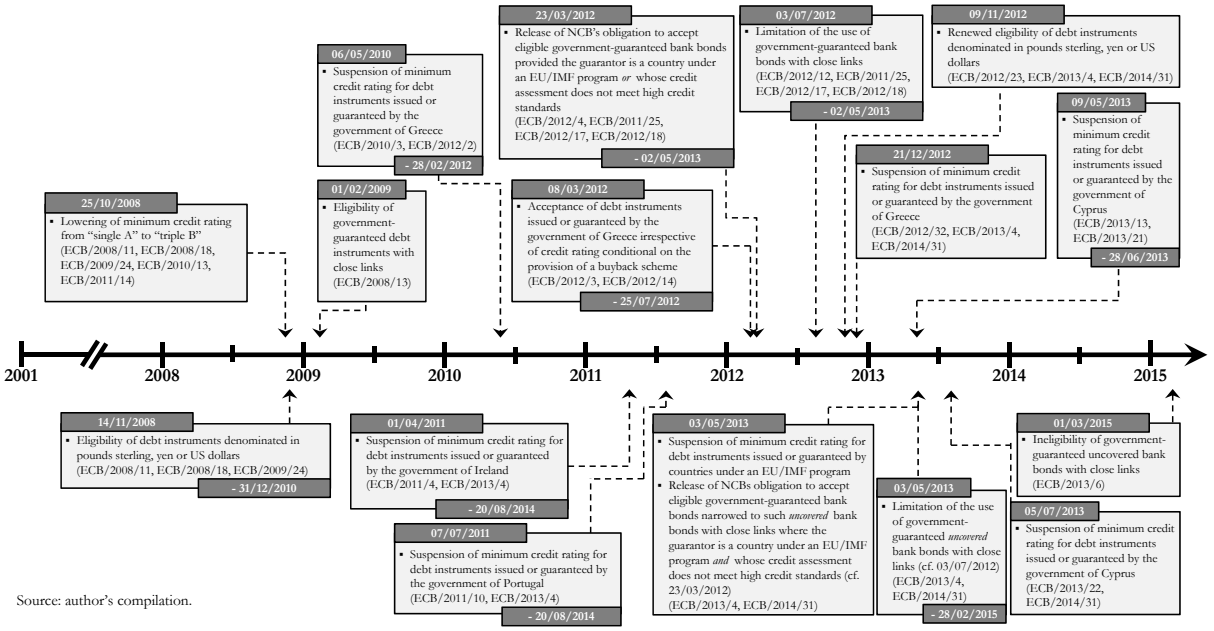
term debt instruments issued by non-financial corporations that do not comply with general collateral criteria.

3.2.2 Changes to the Collateral Criteria of Government-Linked Securities

This section examines the amendments to collateral criteria of debt instruments issued or guaranteed by public entities (with the right to levy taxes, hereafter referred to as governments) depicted in Figure 3.3.[81]

Figure 3.3: Changes to the collateral criteria of government-linked securities

The figure chronologically arranges the amendments to collateral criteria of securities issued or guaranteed by governments. Most importantly, the Eurosystem suspended the minimum credit rating threshold for several crisis-stricken countries, i.e. for Greece (May 2010), Ireland (April 2011 to August 2014), Portugal (July 2011 to August 2014) and Cyprus (May 2013).



Although the minimum rating threshold was already reduced to "triple B" for government-related assets in October 2008 (as for all assets except for ABSs), several countries continued to struggle to meet this threshold. In order to keep debt instruments issued or guaranteed by these countries eligible, the Eurosystem successively suspended the application of the minimum rating threshold to marketable debt instruments issued or guaranteed by these governments, i.e. for Greece (May 2010),[82] Ireland (April 2011 to August 2014), Portugal (July 2011 to August 2014) and Cyprus (May 2013).[83] The Eurosystem extended the eligibility of own-use collateral to government-guaranteed assets in February 2009. In principle, this enabled banks to securitize assets into bonds, ask the government for guarantee and pledge them owing to the government guarantee.

[81] See also Chapter 8 for the importance and fiscal implications of amendments to collateral criteria of government-guaranteed bonds.

[82] The suspension for Greece was repealed in February 2012, before being suspended again from March 2012 to July 2012. Reintroduced suspension was conditional upon the Greek government's ability to provide collateral enhancement in the form of a buy-back scheme. In December 2012, the minimum rating threshold was waived again without further condition.

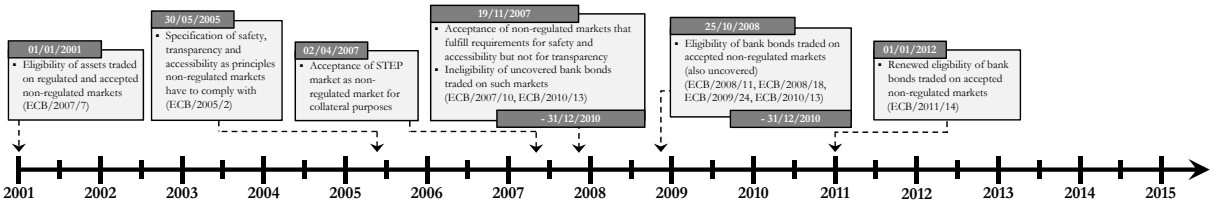
[83] For the Cypriot government, the suspension was repealed in June 2013 and reintroduced in July 2013.

3.2.3 Changes to the Collateral Criteria of Securities Traded on Non-Regulated Markets

The requirement for marketable assets to be traded on accepted regulated and non-regulated markets was already contained in the initial collateral framework.[84] The Eurosystem successively modified its requirements, thereby increasing the number of accepted non-regulated markets over time.[85] Figure 3.4 illustrates the development of collateral criteria of assets traded on accepted non-regulated markets in due consideration of the market for Short-Term European Papers (STEPs, see below) as a controversial example for a non-regulated market.

Figure 3.4: Changes to the collateral criteria of securities traded on non-regulated markets

The figure illustrates the development of the collateral criteria of assets traded on non-regulated markets from 2001 to 2014. It reveals that the Eurosystem initially refined requirements for accepted non-regulated markets to standardize the collateral framework but deviated from this approach during the financial crisis. Most importantly, the Eurosystem deemed eligible uncovered bank bonds traded on non-regulated markets, e.g. the Short-Term European Paper (STEP) market.



Source: author's compilation.

The Eurosystem refined the requirements with which accepted non-regulated markets had to comply in May 2005 for the purpose of creating a comprehensive collateral framework. The Eurosystem referred to three principles according to which non-regulated markets were assessed, i.e. *(i)* safety, *(ii)* transparency and *(iii)* accessibility.[86] Moreover, the Eurosystem pointed out that it would not aim at assessing the intrinsic quality of each market.

The Eurosystem brought into force an amendment in November 2007 to expand the eligibility of assets traded on non-regulated markets when the first indication of distress in interbank markets appeared. It continued accepting marketable assets other than uncovered bank bonds that had been issued prior to May 2007 in certain non-regulated markets not fully complying with the three principles.[87] Specifically, these were non-regulated markets that fulfilled the requirements for safety and accessibility, although not for transparency.

As distress in interbank markets aggravated in the fall of 2008, bank bonds issued on accepted non-regulated markets were deemed eligible in October 2008, subject to an add-on haircut.[88]

[84] For a market to be considered as regulated, it has to comply with criteria as defined according to the Investment Services Directive (*93/22/EEC*), while accepted non-regulated markets have to comply with certain principles defined by the Eurosystem (see Footnote 86).

[85] In January 2007, the list of accepted non-regulated markets comprised 18 markets from 11 countries. MTS Slovenia was accepted in February 2009 and the Irish Global Exchange Market in January 2013.

[86] According to Guideline *ECB/2005/2*, the principle of safety meant certainty regarding transactions, particularly concerning the validity and enforceability of transactions. Transparency was interpreted as unimpeded access to information on the market's rules of procedures and operation, the financial features of the assets, the price formation mechanism and the relevant prices and quantities. Finally, accessibility referred to a market's rules of procedures and operation, which allowed the Eurosystem to obtain information and conduct transactions when needed for these purposes.

[87] The amendment was prolonged in October 2009 and remained valid until December 2010.

[88] For an extensive discussion of the evolution of collateral criteria applied to bank bonds, see Section 3.2.4.

Eligibility was prolonged twice in December 2008 and January 2010, until December 2010. It was adopted in the General Framework in January 2012 and the add-on haircut was scrapped.

Whenever acceptance requirements for non-regulated markets are sufficiently strict, risk to the Eurosystem stemming from the eligibility of assets traded on such markets should not significantly differ from the risk of assets traded on regulated markets. However, two arguments can be adduced to challenge this view. First, the Eurosystem itself declared that it would not aim at assessing the intrinsic quality of each non-regulated market. Second, the application of the three principles laid down for acceptance of non-regulated markets may be questioned. The principle of *transparency* should guarantee "unimpeded access to information on market rules of procedures and operations, the financial features of the assets, the price formation mechanism, and the relevant prices and quantities" (ECB 2005, p. 35). This principle was not only repeatedly suspended (see above) but also laxly applied, as the following paragraph will discuss.

The STEP Market as Accepted Non-Regulated Market

A notable example of an accepted non-regulated market is the STEP market, which the Eurosystem included into its list of eligible non-regulated markets in April 2007.[89] For a STEP to be eligible, it had to comply with the collateral criteria for the specific asset type. Depending on the issuer, STEPs can be "uncovered bank bonds", "corporate bonds" or "other marketable assets". Although STEPs were principally eligible as collateral, STEPs issued by banks were excluded. However, the Eurosystem revoked this derogation in October 2008, as discussed above.

Figure 3.5 illustrates the development of the size of the STEP market. It reveals that a trebling of the nominal value of STEPs outstanding accompanied the announcement that the Eurosystem would accept the STEP market as a non-regulated market in September 2006. Another increase can be observed in October 2008, at the same time when STEPs issued by banks were deemed eligible. Subsequently, the value of STEPs outstanding persisted at a high level. Without claiming causal effects, the figure suggests that the concurrence of the market development and eligibility of STEPs increased the amount of eligible collateral.[90]

Moreover, the STEP market indicates why the acceptance of non-regulated markets for collateral purposes could pose substantial risk to the Eurosystem (see also Sinn 2012, 2014b). The STEP market is managed by a sub-organization of the European Banking Federation and supervised by the Banque de France. Detailed data on traded STEPs is provided by Euroclear France to the Banque de France, although it is not fully reported to the ECB. This lack of disclosure of information lies in contrast to the Eurosystem's principle of transparency.

3.2.4 Changes to the Collateral Criteria of Bank Bonds

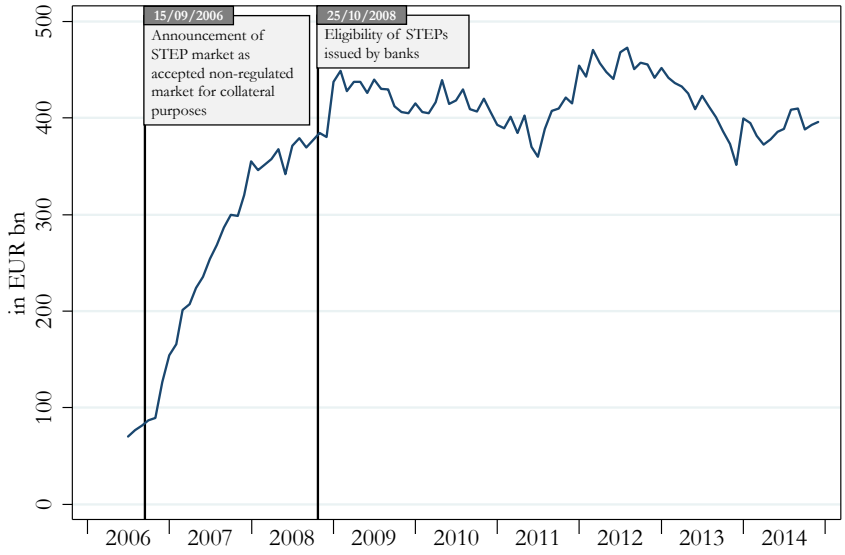
STEPs issued by banks are just one specific type of bank bonds that the Eurosystem deems eligible as collateral. Generally, bank bonds are marketable assets and hence the general collateral

[89] See ECB, "First Publication of STEP Yield Statistics," *Press Release*, 2 April 2007, and ECB, "Assessment of STEP for Collateral Purposes in Eurosystem Credit Operations," *Press Release*, 15 September 2006.

[90] The importance of the acceptance of the STEP market for providing additional collateral is further addressed in Section 3.3.6.

Figure 3.5: The size of the Short-Term European Paper (STEP) market

The figure depicts the development of the size of the STEP market in terms of the nominal value of STEPs outstanding from 2006 to 2014. It indicates that both the announcement of the STEP market as an accepted non-regulated market and the eligibility of STEPs issued by banks coincided with increases in the nominal value of outstanding STEPs.



Source: author's illustration; European Central Bank.

criteria as described in Section 3.2.1 apply. In addition, specific eligibility criteria were established for bank bonds, the development of which is discussed in the following and summarized in Figure 3.6. One can differentiate between covered and uncovered bank bonds. For covered bank bonds, an important distinction is made regarding the compliance of the bonds with the UCITS Directive, see Footnote 55. Moreover, both covered and uncovered bank bonds can imply close links or even be own-use.

3.2.4.1 Initial Collateral Criteria of Bank Bonds

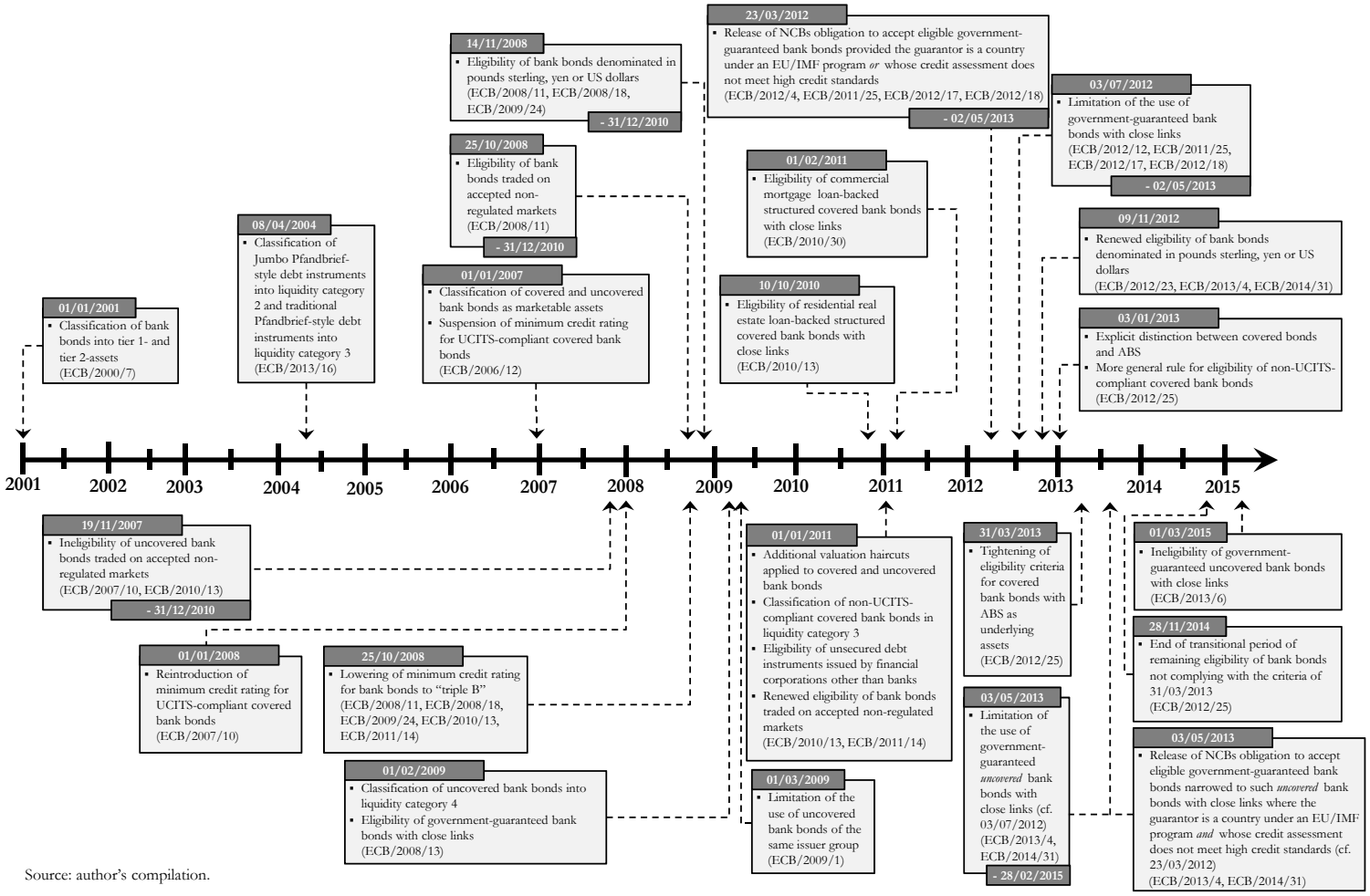
Initially, covered bank bonds had to comply with the UCITS Directive to be eligible within tier 1, where they were classified into either LC 2 or 3. While "Jumbo Pfandbrief-style debt instruments" were included in LC 2,[91] "traditional Pfandbrief-style debt instruments" and all other eligible covered bank bonds were assorted in LC 3. Non-UCITS-compliant covered as well as uncovered bank bonds were only eligible provided that an NCB included them in its tier 2 list. Owing to a similar structure, covered bank bonds were initially considered equivalent to ABSs, but not vice versa.[92]

[91] "Jumbo Pfandbrief-style instruments" were defined as debt instruments with an issuing volume of at least EUR 500 mn, for which at least two market makers provided regular bid and ask prices. All other Pfandbrief-style debt instruments were labeled as "traditional".

[92] The major difference between covered bonds and ABSs is that covered bonds usually remain on the issuer's balance sheet and are typically more regulated, while ABSs are usually off-balance sheet and generally tranched.

Figure 3.6: Changes to the collateral criteria of bank bonds

The figure illustrates the development of the collateral criteria of covered and uncovered bank bonds from 2001 to 2014. It reveals that there were numerous changes to the eligibility of bank bonds, particularly following the onset of the financial crisis. Accordingly, bank bonds were the asset type subject to the most amendments to collateral criteria.



Source: author's compilation.

3.2.4.2 Amendments to Collateral Criteria of Bank Bonds

The Eurosystem deviated from the equivalent treatment of covered bank bonds and ABSs as of May 2006 by clarifying additional specific eligibility criteria were to be met for ABSs (see Section 3.2.5).[93] Moreover, UCITS-compliant covered bank bonds did not have to meet the minimum credit rating threshold from January 2007 to December 2007. Uncovered bank bonds ("debt instruments other than covered bank bonds that are issued by credit institutions", ECB 2006a) were deemed eligible with the introduction of the Single List in January 2007, provided that they were admitted to trading on a regulated market.

Amendments to the liquidity classifications of bank bonds were performed in February 2009 and January 2011.[94] In February 2009, "jumbo covered bank bonds" were marked as LC 2,[95] "traditional covered bank bonds" as LC 3, and all uncovered bank bonds ("credit institution debt instruments, unsecured") were reclassified from LC 3 into LC 4, just like "unsecured debt instruments issued by financial corporations other than banks" in January 2011. Furthermore, all non-UCITS-compliant covered bank bonds were explicitly included into LC 3.

The Eurosystem had to cope with the potential perils stemming from the eligibility of bank bonds guaranteed by crisis-stricken countries irrespective of credit rating (see Section 3.2.2) when the fiscal positions of European governments deteriorated. As of March 2012, NCBs were thus exempted from their obligation to accept eligible *bank bonds* guaranteed by countries under an EU/IMF program *or* by countries whose credit assessment did not comply with the minimum credit rating.[96] This attempt to mitigate risk was alleviated in May 2013 when the exemption was narrowed to *uncovered* bank bonds *with close links* guaranteed by countries under an EU/IMF program *and* whose credit assessments did not meet the minimum credit rating.[97]

In the same line of risk precaution, the pledge of uncovered bank bonds has been limited as of March 2009. Since then, uncovered bank bonds of the same issuer group (i.e. identical issuer or closely linked issuers) could only be pledged to the extent that the haircut-adjusted value of these bonds would not exceed 10% of the total value of the collateral submitted by the counterparty. The limitation was further tightened to 5% in January 2012 and it was generalized to all unsecured debt instruments (i.e. issued by credit institutions and also by any other institution) in October 2010. Hence, excessive exposure to one counterparty and its affiliates was counteracted and the potential mutual provision of collateral between two banks

[93] However, the Eurosystem did not explicitly distinguish between covered bonds and ABSs before January 2013, when it emphasized that "for the purpose of the Eurosystem legal framework related to monetary policy, covered bonds are not considered ABSs" (ECB 2012d, p. 32).

[94] These amendments are important as the Eurosystem performs risk control based on liquidity classifications, i.e. it applies haircuts according to liquidity classifications.

[95] The requirements for a debt instrument to be classified as "Jumbo covered bank bond" (previously: "Jumbo Pfandbrief-style debt instrument") were modified whereby the issuing volume was increased from EUR 500 mn to at least EUR 1 bn and at least three market makers (instead of two) had to provide regular bid and ask quotes, see also Footnote 91.

[96] For instance, the Deutsche Bundesbank decided to refuse such uncovered bank bonds from Greece, Portugal and Ireland as of May 2012, according to Nagel 2012.

[97] As of March 2015, uncovered bank bonds with close links are ineligible such that these provisions lapse.

was limited. However, government-guaranteed uncovered bank bonds were excluded from any limitation.[98]

The Eurosystem restricted the pledge of covered bank bonds in March 2013 by introducing additional collateral criteria. Since then, the Eurosystem has prohibited the pool of assets underlying covered bank bonds to contain ABSs. Exemptions were made with respect to several specific types of ABSs.[99] Moreover, the restrictions did not apply to covered bank bonds that had been on the list of eligible ABSs by November 2012. These bonds remained eligible until November 2014.

3.2.4.3 Eligibility of Bank Bonds with Close Links

The general eligibility of marketable assets with close links has already been addressed in Section 3.1.4.1. The general collateral criteria were also applied to bank bonds with close links. Moreover, the Eurosystem applied specific criteria to bank bonds with close links, the development of which is captured in Table 3.1 and discussed hereafter.[100]

Initially, only UCITS-compliant covered bank bonds with close links were deemed eligible. In October 2010, eligibility was extended to certain non-UCITS-compliant covered bank bonds, i.e. residential real estate loan-backed structured covered bank bonds. The eligibility of non-UCITS-compliant covered bank bonds was extended to those backed by commercial mortgage loans in February 2011. A more general rule for the eligibility of bank bonds with close links was established in January 2013, referring to any "covered bank bonds for which all criteria set out in Part 1, Points 68 to 70 of Annex VI to Directive 2006/48/EC are complied with, except for the limits on guaranteed loans in the cover pool" (ECB 2012d, p. 34).

Government-guaranteed bank bonds with close links became eligible in February 2009 (see Section 3.2.2). Such bonds could be substantially pledged as no limitation was in place prior to July 2012.[101] In July 2012, the Eurosystem limited the pledge of such bonds to the nominal value of bonds submitted by 3 July 2012 (i.e. the day when the relevant guideline entered into force). However, the Eurosystem defined this restrictive measure down by making deviations from the limitation possible subject to Council approval. Moreover, the Eurosystem narrowed the limitation to government-guaranteed *uncovered* bank bonds with close links in May 2013. As of March 2015, the Eurosystem no longer accepts as collateral government-guaranteed uncovered bank bonds with close links as well as covered bonds with such bank bonds in the underlying pool.

[98] Moreover, the limitation was waived for uncovered bank bonds with a haircut-adjusted total value of less than EUR 50 mn and for bonds already submitted as collateral prior to 20 January 2009. The latter exception was valid until 1 March 2010.

[99] Specifically, the following ABSs remained allowed in the underlying pool of covered bank bonds: *(i)* ABSs that complied with the requirements laid down in Directives *2006/48/EC* and *2006/49/EC*; *(ii)* ABSs that were originated by a member of the same consolidated group of which the issuer of the covered bonds is also a member; or *(iii)* ABSs that are used as a technical tool to transfer mortgages or guaranteed real estate loans from the originating entity into the cover pool. See *ECB/2012/25*.

[100] As the Eurosystem did not explicitly distinguish between covered bank bonds and ABSs for collateral purposes prior to January 2013, changes to the application of close links to covered bank bonds are also indicated as changes to ABSs (but not vice versa) until that date.

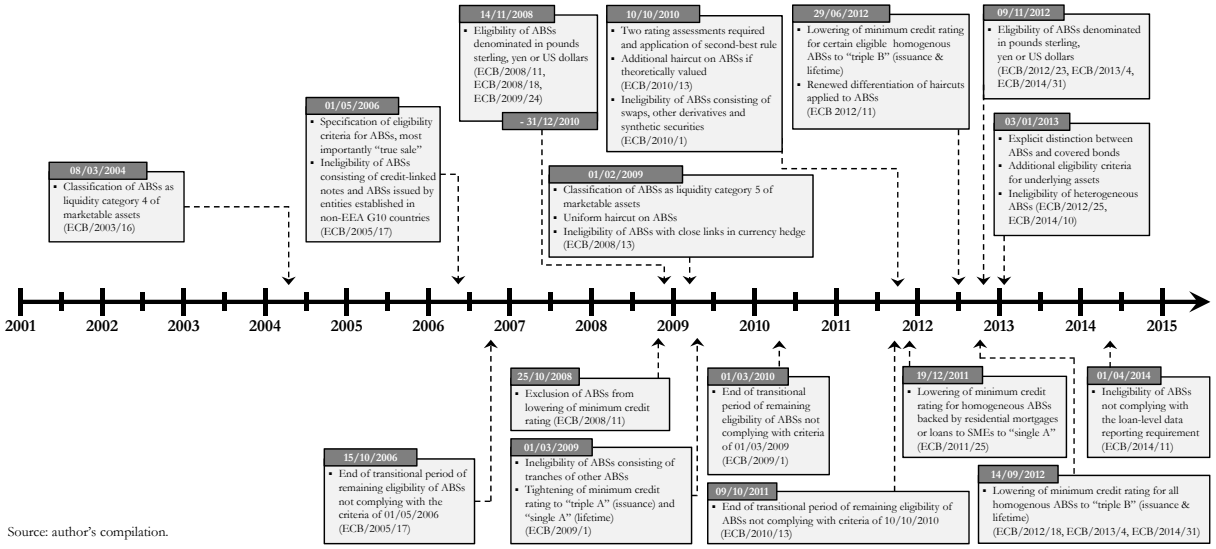
[101] See Chapter 8 and Sinn 2014b.

3.2.5 Changes to the Collateral Criteria of Asset-Backed Securities

Like covered bank bonds, ABSs are a possible way for banks to free up the balance sheet, although banks have preferred the former over the latter for two reasons: first, most covered bank bonds can be used as collateral even with close links; and second, lower haircuts were applied to covered bank bonds than to ABSs (see Section 4.2.2). It was discussed in the previous section that the Eurosystem did not explicitly differentiate between ABSs and covered bank bonds prior to January 2013.[102] Therefore, it is presumed that collateral criteria specified for covered bank bonds were also applied to ABSs prior to May 2006, when the Eurosystem first set out ABSs-specific collateral criteria. These ABSs-specific criteria are discussed in the following and summarized in Figure 3.7.

Figure 3.7: Changes to the collateral criteria of asset-backed securities (ABSs)

The figure illustrates the development of collateral criteria of ABSs from 2001 to 2014, marking a story of both tightening and relaxation. During a first period between 2006 and 2011, the Eurosystem limited the eligibility of ABSs but relaxed requirements thereafter (2011 to 2012). Since January 2013, a tight accompanying monitoring of underlying assets has been introduced.



The development of ABSs-specific criteria marks a story of both tightening and relaxation. During a first period between 2006 and 2011, the Eurosystem limited the eligibility of ABSs but relaxed criteria thereafter (2011 to 2012). Since January 2013, it has started to introduce a tight accompanying monitoring of assets underlying ABSs.

3.2.5.1 Tightening Collateral Criteria of ABSs (2006-2011)

ABSs were excluded from the requirement for eligible assets to have a fixed and unconditional principal amount introduced in May 2006. However, specific requirements were laid down for assets underlying ABSs, i.e. they had to be legally acquired in accordance with the laws of an EU member state and be a "true sale" that was enforceable against any third party and beyond

[102] ABSs were not explicitly included in the initial collateral framework. They were first mentioned in March 2004 and classified into LC 4, i.e. the lowest category possible at that time. The classification was irrespective of the issuer or credit rating.

the reach of the originator and its creditors.[103] Furthermore, two types of ABSs were deemed ineligible: *(i)* ABSs comprising credit-linked notes; and *(ii)* ABSs issued by entities established in non-EEA G10 countries, i.e. the US, Canada, Japan and Switzerland. ABSs not complying with these criteria remained eligible until October 2006.

The Eurosystem explicitly excluded ABSs from the lowering of the minimum credit rating threshold for marketable and non-marketable assets in October 2008. Soon afterwards, the minimum credit rating requirement for ABSs was even tightened in March 2009. The Eurosystem defined its high credit standards for ABSs as "single A" over the *lifetime* of the ABSs and the highest possible credit rating of "triple A" had to be obtained at *issuance*. At the same time, the Eurosystem further restricted the criteria for underlying assets. Multiple securitization was foreclosed by the prevention that underlying assets could comprise tranches of other ABSs. ABSs that did not meet the restrictions but were issued prior to 1 March 2009 remained eligible for another year. ABSs were shifted to (the lowest) LC 5 when uncovered bank bonds were introduced into LC 4 in February 2009. As of October 2010, the Eurosystem required at least two ECAIs-credit ratings to meet the minimum credit rating thresholds for ABSs. In case of distinct ratings, the "second-best rule" was applied.[104] The application of this second-best rule lies in contrast to the treatment of all other assets for which the less strict first-best rule was applied, see Section 3.1.4.3. With respect to underlying assets, the Eurosystem also demanded that ABSs should not comprise swaps, other derivatives or synthetic securities.[105]

3.2.5.2 Relaxing Collateral Criteria of ABSs (2011-2013)

The Eurosystem changed course in December 2011, abandoning its restrictive collateral policy with respect to ABSs. It lowered the minimum credit rating threshold for specific ABSs with only one sort of underlying assets, i.e. homogeneous ABSs.[106] For ABSs backed by loans to small and medium enterprises (SMEs) or residential mortgages only, the minimum rating threshold at issuance was lowered from a second-best rating of "triple A" to "single A".[107] Such ABSs were considered eligible provided that they fulfilled additional criteria.[108]

The lowering of the rating threshold was intended to be sustained until September 2012. Nevertheless, it was further lowered in June 2012 to a second-best rating of "triple B" both at issuance

[103] "True sale" means that the underlying assets are transferred by the seller to a special purpose vehicle (SPV), which becomes entitled to the cash flows generated by the underlying assets (including those resulting from a sale of the assets).

[104] Depending on the date of issuance, the Eurosystem implemented the following regimes. For ABSs issued prior to 1 March 2010 with only one credit assessment, an additional assessment had to be obtained before 1 March 2011. For ABSs issued before 1 March 2009, both credit assessments had to meet a rating of at least "single A" over lifetime. For ABSs issued between 1 March 2009 and 28 February 2010, the first-best credit assessment had to comply with "triple A" at issuance and "single A" over lifetime and the second-best assessment with "single A" both at issuance and over lifetime.

[105] This requirement did not prevail for swaps used in ABSs transactions strictly for the purpose of hedging. ABSs that did not comply with this requirement but had been eligible before October 2010 were deemed eligible for another year.

[106] The Eurosystem thereby made a move towards accepting only ABSs considered as "plain vanilla", i.e. ABSs made from a single pool of underlying assets.

[107] The minimum rating requirement over lifetime was kept at "single A".

[108] First, the counterparty pledging the ABSs or any third party with close links was not allowed to provide an interest rate hedge . Second, the underlying assets were not allowed to contain loans that were non-performing at issuance nor structured, syndicated or leveraged at any time.

and over lifetime. Moreover, this lowering was not made exclusive for ABSs backed by loans to SMEs or residential mortgages only, but it also applied to homogeneous ABSs from commercial mortgages, auto loans as well as leasing and consumer finance and heterogeneous ABSs comprising loans to SMEs and residential mortgages.[109] Since July 2014, credit card receivables have been added to the list of assets underlying homogenous eligible ABSs.

3.2.5.3 Tightening the Monitoring of Eligible ABSs (as of January 2013)

Since January 2013, ABSs have occupied an exceptional role within marketable assets as an explicit differentiation has been made between "common eligibility requirements" and "additional eligibility criteria applicable to ABSs". The "loan-level reporting initiative" was gradually introduced, aimed at making ABSs in general and the underlying assets in particular more transparent. Accordingly, the Eurosystem demanded comprehensive and standardized loan-level data on the pool of underlying assets.[110] ABSs must be backed by homogeneous assets; otherwise, the underlying assets cannot be reported in accordance with the loan-level reporting requirement.[111] Therefore, heterogeneous ABSs have been deemed ineligible as of January 2013 and any other ABSs not complying with the loan-level reporting requirement as of April 2014.

3.2.5.4 Collateral Criteria of ABSs with Close Links

For ABSs with close links, asset-specific collateral criteria beyond general criteria discussed in Section 3.1.4.1 were put into force (see also Table 3.1). As the Eurosystem did not explicitly differentiate between covered bank bonds and ABSs prior to January 2013, it is presumed that the development of the eligibility of covered bank bonds with close links (Section 3.2.4.3) also touches upon the eligibility of ABSs with close links.

3.2.6 Changes to the Collateral Criteria of Corporate Bonds

Corporate bonds were labeled as "debt instruments issued by corporate and other issuers" (ECB 2003),[112] and they have always been eligible for collateral purposes provided that they comply with the general collateral criteria for marketable assets. Thus, corporate bonds were also subject to the general changes of collateral criteria applied to marketable assets extensively discussed in Section 3.2.1, without specific provisions having been made.

[109] At first, this lowering was temporarily valid until September 2012, before being prolonged in September 2012 until March 2013. In March 2013, it was included in the General Framework.

[110] Loan-level reporting requirements were introduced for residential mortgage-backed securities (RMBSs) as well as ABSs backed by loans to SMEs on 1 January 2013. Since 1 March 2013, the requirements have also been imposed to commercial mortgage-backed securities (CMBSs). For consumer finance ABSs, leasing ABSs and auto loan ABSs, the requirements became obligatory as of 1 January 2014 and for credit card ABSs by 1 April 2014.

[111] The underlying assets were to be reported using a single template for the specific asset type to meet the loan-level requirement, which could not be fulfilled for heterogeneous ABSs.

[112] The label was changed to "debt instruments issued by non-financial corporations and other issuers" (ECB 2010b) in January 2011.

3.2.7 Preliminary Summary

Thus far, this chapter has aimed to provide an in-depth analysis of the Eurosystem collateral framework and its development in terms of a narrative database. Table 3.3 summarizes the most important amendments to the collateral criteria performed by the Eurosystem between 2001 and 2014, indicating the amendments as tightening or relaxing the collateral criteria accordingly.

Table 3.3: Summary and classification of major amendments to collateral criteria

The table consolidates the narrative database of the Eurosystem collateral framework by pointing out and classifying the most significant amendments. The table conveys the overall impression that *(i)* the Eurosystem intensified amendments to the collateral framework throughout recent years of crisis, and that *(ii)* activity was predominantly directed at relaxing collateral criteria.

Date	Amendment	Classification	
		tightening	relaxing
30/05/2005	ineligibility of equities	✓	
01/01/2007	abolition of idiosyncratic collateral criteria (introduction of Single List)	✓	
15/09/2008	collapse of Lehman Brothers		
25/10/2008	lowering of minimum credit rating for all assets except for ABSs from "single A" to "triple B";		✓
	eligibility of bank bonds traded on STEP market		✓
14/11/2008	eligibility of marketable debt instruments issued in pounds sterling, yen or US dollars		✓
01/02/2009	eligibility of own-use government-guaranteed debt instruments;		✓
	DBRS accepted as fourth ECAI		✓
01/03/2009	increase of minimum credit rating for ABSs from "single A" to "triple A" at issuance	✓	
05/2010	intensification of European sovereign debt crisis		
06/05/2010, 01/04/2011, 07/07/2011, 03/05/2013, 09/05/2013	suspension of minimum credit rating for debt instruments issued or guaranteed by the governments of Greece, Ireland, Portugal; later by governments under an EU/IMF program and Cyprus		✓
19/12/2011	idiosyncratic acceptance of credit claims by NCBs;		✓
	lowering of minimum credit rating for specific ABSs from "triple A" to "single A" at issuance		✓
29/07/2012	lowering of minimum credit rating for all ABSs from "single A" to "triple B" at issuance and over lifetime		✓
03/01/2013	ineligibility of heterogeneous ABSs	✓	
01/04/2014	ineligibility of ABSs not complying with the loan-level reporting requirement	✓	

Source: author's compilation.

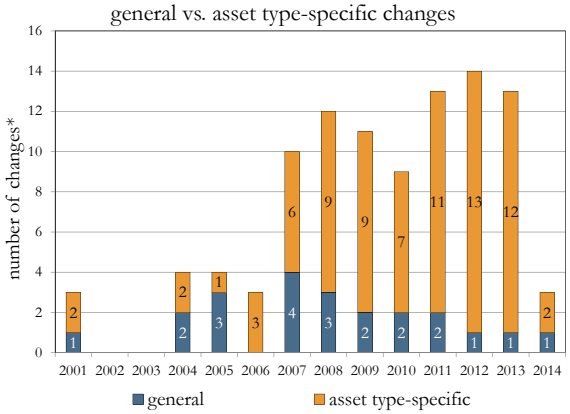
The table conveys the overall impression that *(i)* the Eurosystem intensified amendments to the collateral framework in response to the financial crisis, and that *(ii)* activity was predominantly directed at relaxing collateral criteria. This impression arises from a qualitative consideration and is reinforced by the quantitative dimension reflected in Figure 3.8.[113] The figure reveals how amendments to collateral criteria scatter over time. While changes were scarce prior to the financial crisis, the Eurosystem ramped up activity as of 2007, whereby the number of changes

[113] Moreover, the Eurosystem released only six official documents affecting collateral criteria prior to the financial crisis. From the onset of the crisis in 2008 to the end of 2014, this number increased to 44.

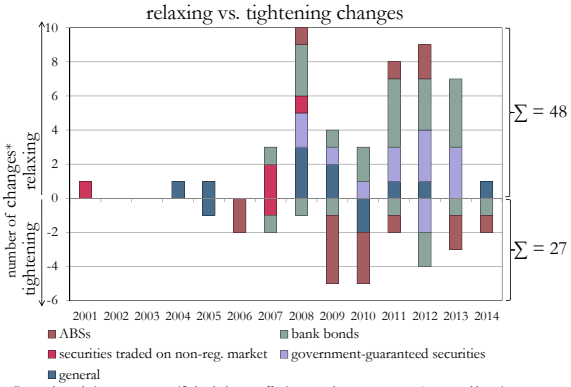
increased from 25 prior to 74 after the Lehman event. While amendments were rather general as a first response to the financial crisis, the Eurosystem refined changes over the years towards asset type-specific criteria. In Figure 3.8, the changes are classified as either tightening or relaxing measures. Changes that cannot be classified accordingly are neglected. The bars sum up changes in either direction differentiated by asset type. Relaxing measures prevail in response to the financial crisis (particularly in 2008) and throughout the European sovereign debt crisis. Overall, 48 relaxing and 27 tightening amendments can be identified since the introduction of the collateral framework in 2001.

Figure 3.8: Temporal distribution of classified amendments to collateral criteria

The figure reveals the chronological distribution of changes to collateral criteria from 2001 to 2014 according to the author's compilation. The left panel differentiates between changes applying to all assets ("general") and changes to specific asset types ("asset type-specific"). The Eurosystem ramped up activity as of 2007 and refined activity over the years towards amending asset type-specific criteria. The right panel shows the author's classification of the changes as either tightening or relaxing. The panel indicates that relaxing changes prevail during both the financial crisis and the European sovereign debt crisis.



*Due to the analysis on an asset-specific level, changes affecting more than one asset type (e.g. general lowering of minimum credit rating) may be included multiply.
Source: author's compilation.



*Due to the analysis on an asset-specific level, changes affecting more than one asset type (e.g. general lowering of minimum credit rating) may be included multiply.
Source: author's compilation.

The narrative database of changes to the Eurosystem collateral framework presented in this chapter thus far indicates that the Eurosystem broadened the collateral pool both *horizontally* and *vertically*.[114] Horizontally, it broadened the collateral pool *quantitatively*, i.e. it deemed eligible additional asset types of given credit quality. Vertically, the Eurosystem broadened the pool *qualitatively* by lowering the minimum credit rating threshold for given types of eligible asset types. The next section elaborates on the broadening along both dimensions by analyzing the development of the size and composition of the collateral pool.

3.3 Development of the Pool of Eligible Marketable Assets (Collateral Pool)

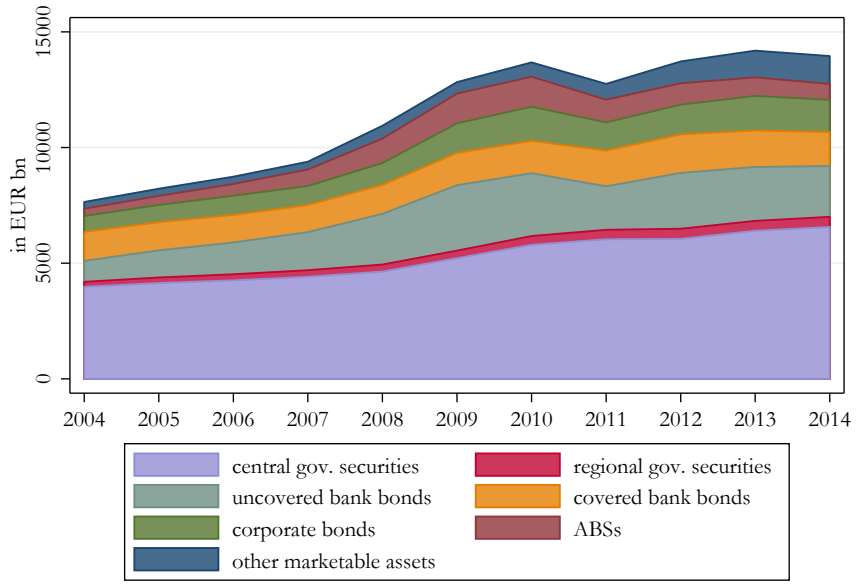
Information published by the ECB on the development of the collateral pool is depicted in Figure 3.9. The ECB only provides historical data in aggregated terms, i.e. data on eligible marketable assets by asset type, only yearly from 2004 to 2011 and quarterly since 2012.[115] No record is available for eligible non-marketable assets as these are usually traded over the

[114] Chailloux et al. 2008b make an akin differentiation but refer to the horizontal dimension as the currencies that are accepted.
[115] For the sake of comparability, Figure 3.9 uses yearly data only.

counter.[116] Therefore, Figure 3.9 shows the total nominal value of eligible marketable assets by asset type and reveals that the collateral pool changed in two ways: the pool substantially grew from 2004 to 2014 (by 82.5%), while its composition varied. The only year in which the pool contracted relative to the previous year was 2011, which can be attributed to the expiration of two major relaxations of the collateral framework: *(i)* the eligibility of bank bonds traded on non-regulated markets; and *(ii)* the eligibility of assets denominated in certain foreign currencies. The two amendments were reintroduced throughout 2012 such that the collateral pool recovered thereafter.

Figure 3.9: Published information on eligible marketable assets (Eurosystem collateral pool)

The figures shows the development of the Eurosystem collateral pool by asset type from 2004 to 2014, based on data published by the ECB. It reveals that the collateral pool substantially increased during that time. Owing to the availability of highly-aggregated data only, the lessons from the figure are limited.



Source: author's illustration; European Central Bank.

The lessons from published data given in Figure 3.9 are limited for two reasons: *(i)* data is aggregated for asset types such that asset-specific information is not available; and *(ii)* data is averaged over end-of-month stocks at the end of each year/quarter such that time-specific information is not available. The remainder of this section aims to reveal new insights into the effects of amendments to collateral criteria on the development of the collateral pool by investigating both asset- and time-specific information. Therefore, it refines information provided in Figure 3.9 for the major crises period from May 2007 to December 2013. This refinement is based on historical data from the Eligible Assets Database provided to the author by the Deutsche Bundesbank. The Eligible Assets Database is the list of all eligible marketable assets on ISIN-basis and hence it may comprise up to 50,000 unique marketable assets.[117] The ECB has published the list daily since April 2010. As the list is only published for the day, no historical record is available from the ECB. Based on end-of-month lists of eligible marketable

[116] Hence, the following analysis is limited to the extent that only eligible *marketable* assets are investigated.

[117] It comprised 25,348 marketable assets with a nominal value of EUR 9.9 tn in May 2007, 51,374 assets (EUR 11.6 tn) in November 2008 and 36,930 assets (EUR 13.9 tn) in December 2013.

assets from May 2007 to December 2013, Figure 3.9 is refined and extended in the following, providing new insights into the development of the collateral pool along different dimensions.[118] The analysis of the monthly stock of eligible marketable assets (collateral pool) is complemented by the investigation of the monthly flow of eligible marketable assets (newly eligible marketable assets). While the analysis of the collateral pool contributes to obtain holistic insights into the development of eligible marketable assets along various dimensions, the investigation of newly eligible assets better fits for tracking the effects of amendments to the collateral framework on eligible assets.

3.3.1 Refinement of the Collateral Pool Development

Figure 3.10 refines Figure 3.9 by revealing the development of the collateral pool by country (left panel) and asset type (right panel) based on monthly data from May 2007 to December 2013.[119] The right panel confirms the observations from Figure 3.9 that the collateral pool substantially increased from 2007 to 2013 and that its composition also changed. This can be attributed to the numerous changes to general collateral criteria that affected all asset types. However, the value of eligible ABSs decreased over time—an observation that can be referred to both market developments and the stricter collateral criteria of ABSs. Furthermore, the eligible amount of uncovered bank bonds increased, particularly after the onset of the financial crisis, which triggered changes to collateral criteria, e.g. with respect to bank bonds traded on accepted non-regulated markets. The left panel illustrates that the geographical distribution of eligible assets changed over time, e.g. while the nominal value of eligible assets in Germany remained relatively constant, it increased in France and Italy. Although amendments to the collateral framework were broadly defined and affected all asset types, their effects obviously differed across countries, which led to asymmetrical geographical developments.

3.3.2 Newly Eligible and Ineligible Marketable Assets

The analysis of the monthly stock of eligible marketable assets (collateral pool) in the previous section is complemented by the investigation of the monthly flow of eligible marketable assets (newly eligible marketable assets) as amendments to collateral criteria determine assets that enter the collateral pool ("newly eligible assets") or leave it ("newly ineligible assets").[120] Figure 3.11 gives the monthly nominal value of newly eligible and ineligible marketable assets from May 2007 to December 2013. As relaxations of collateral criteria dominated after the onset of the financial crisis, the nominal value of newly eligible collateral is more volatile than the nominal value of newly ineligible. Moreover, the nominal value of newly eligible assets runs on

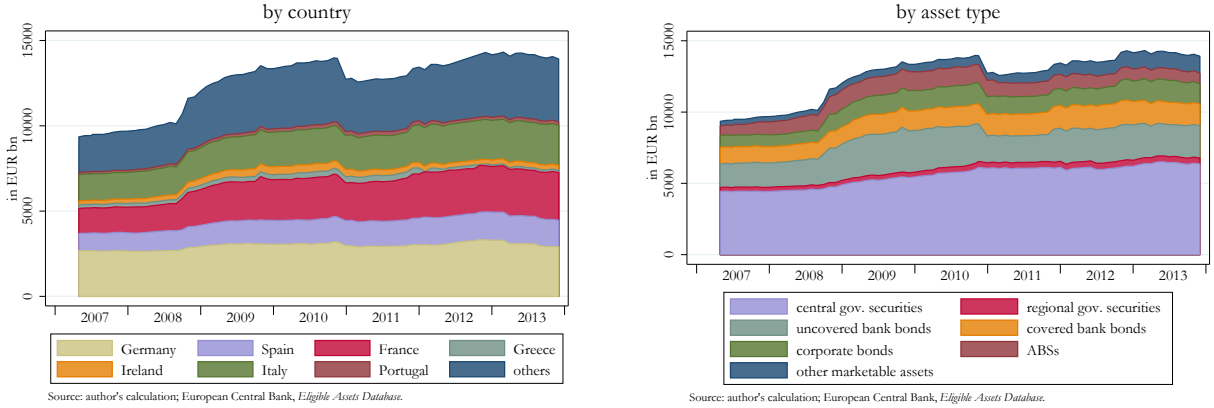
[118] The Eligible Assets Database differentiates between *(i)* bonds, *(ii)* medium-term notes, *(iii)* (treasury) bills/-commercial papers/certificates of deposit, *(iv)* Jumbo covered bonds, *(v)* traditional covered bonds, *(vi)* abs, *(vii)* multi-cédulas, and *(viii)* structured covered bonds. For the sake of comparability, assets based on ISINs were matched to the asset types recognized in Figure 3.9, based on the issuer and asset specification given in the database.

[119] The distribution across countries is calculated in terms of the residence of the collateral issuer.

[120] Newly eligible assets are defined as assets that appear in the collateral pool in one month but not in the previous one. Newly ineligible assets are assets that are contained in the collateral pool in one month but not in the subsequent one, corrected for assets that became ineligible owing to maturity.

Figure 3.10: Refined information on the collateral pool by country and by asset type

The figure refines Figure 3.9 by showing the development of the collateral pool by country (left panel) and asset type (right panel) from May 2007 to December 2013 based on monthly data provided to the author by the Deutsche Bundesbank. The right panel confirms the previous observation that the collateral pool substantially increased, as well as revealing that its composition by asset type changed. Moreover, the left panel indicates that the composition by country changed over time, implying asymmetrical developments of eligible marketable assets in selected countries.



Source: author's calculation; European Central Bank, *Eligible Assets Database*.

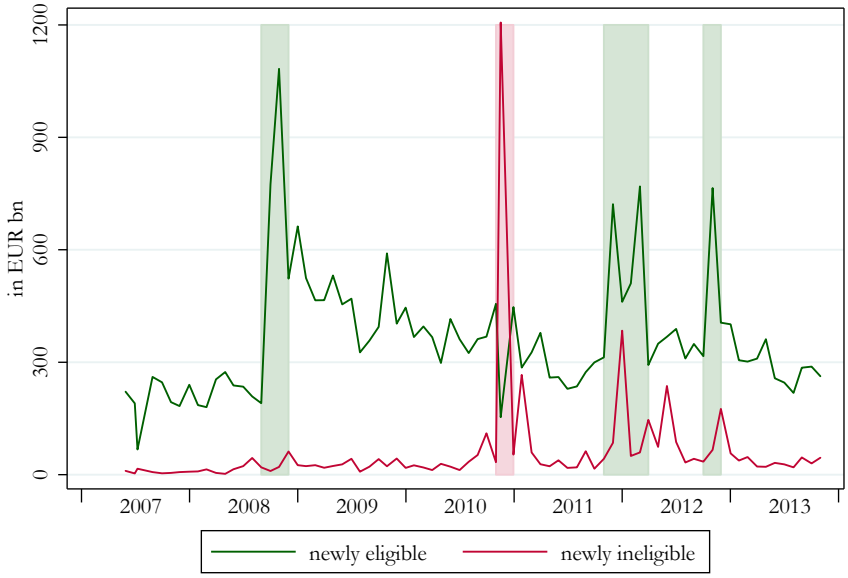
Source: author's calculation; European Central Bank, *Eligible Assets Database*.

a higher level than newly ineligible assets as the collateral pool grew over time. In December 2010, the value of newly ineligible assets jumps as in January 2011 both bank bonds traded on non-regulated markets and marketable assets denominated in pounds sterling, yen and US dollars became ineligible. During 2012, several jumps in the value of newly ineligible assets can be attributed to changes to the collateral criteria of bonds issued or guaranteed by the Greek government, e.g. the withdrawal of the suspension of the minimum credit rating for such bonds in February and July 2012. For newly eligible assets, the development is marked by three jumps. The first jump occurred immediately after the onset of the financial crisis in October and November 2008, when the Eurosystem successively introduced the eligibility of lower-rated assets, bank bonds traded on non-regulated markets and assets denominated in pounds sterling, yen and US dollars. The figure shows that these amendments triggered a substantial increase in the nominal value of newly eligible collateral. The second jump lasted from December 2011 to March 2012, with two consecutive substantial increases in the value of newly eligible marketable assets. The jumps can be attributed to the reintroduced eligibility of bank bonds traded on non-regulated markets (January 2012) together with the two three-year LTROs allotted during that time ("big bazooka"). The Eurosystem substantially increased refinancing credit via the two LTROs (see Section 2.3) and this additional credit had to be collateralized, largely by government-guaranteed assets (see Chapter 8). The last jump in November 2012 reflects the reintroduction of the eligibility of assets denominated in pounds sterling, yen and US dollars.

Figure 3.12 investigates the area under the green line in Figure 3.11, i.e. the development of the nominal value of newly eligible assets, by country (left panel) and asset type (right panel). The left panel indicates that newly eligible assets were freed up across all countries and particularly in France and Italy, thus confirming the findings of Figure 3.10. Moreover, other Eurozone countries as well as Great Britain and the US (depicted as "others") gained in importance, most

Figure 3.11: Newly eligible and ineligible marketable assets

The figure shows the development of the nominal value of newly eligible and ineligible marketable assets from 2007 to 2013. As collateral criteria were predominantly relaxed rather than tightened during that time, the nominal value of newly eligible assets is more volatile than the nominal value of newly ineligible assets. As the collateral pool was growing over time, the nominal value of newly eligible collateral runs on a higher level than newly ineligible assets. Jumps in nominal values highlighted by the shaded areas can be attributed to changes in collateral criteria.



Source: author's calculation; European Central Bank, *Eligible Assets Database*.

importantly owing to the eligibility of foreign currency-denominated assets.[121] The right panel reveals that predominantly government bonds and uncovered bank bonds became newly eligible.

3.3.3 Eligible Marketable Assets in Selected Countries

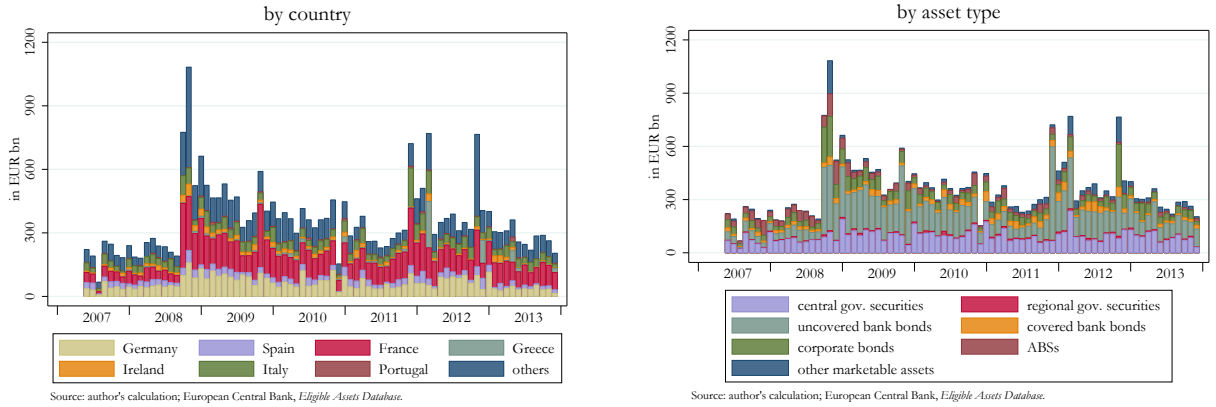
This section merges the analyses for the collateral pool and newly eligible marketable assets and scrutinizes both newly eligible marketable assets and collateral pools in selected countries by asset type. This is supported by Figure 3.13, which considers newly eligible marketable assets in the left panels and national collateral pools (i.e. the pool of eligible marketable assets in each country) in the right panels. The comparison of the panels for each country provides a better understanding of how amendments to collateral criteria affected the development of newly eligible collateral and the composition of national collateral pools.

While the German collateral pool grew only slightly from May 2007 to December 2013 (8%), collateral pools considerably increased in Spain (56.4%), France (90.2%) and Italy (52.3%). The Irish collateral pool substantially increased from the onset of the financial crisis in the fall of 2008 to the end of 2010 (53.5%), while the Portuguese pool steadily increased (63%), although with a dint from May 2012 to April 2013. The Greek collateral pool grew until January 2012 (64.6%) but subsequently dropped to a level lower than in May 2007. In all countries, government bonds accounted for the largest fraction of eligible marketable assets.

[121] As of May 2005, collateral issued by entities from the US, Canada, Japan and Switzerland has been deemed eligible (see Section 3.2.1).

Figure 3.12: Newly eligible marketable assets by country and by asset type

The figure elaborates on the area under the green line in Figure 3.11 and details the development of newly eligible marketable asset by country (left panel) and asset type (right panel) from 2007 to 2013. Although newly eligible collateral was spread across countries, a substantial fraction was issued in France. The right panel confirms that predominantly government and uncovered bank bonds became newly eligible.



Source: author's calculation; European Central Bank, *Eligible Assets Database.*

The composition of the German collateral pool remained relatively stable with covered bank bonds slightly losing importance, being outweighed by uncovered bank bonds and other marketable assets. Moreover, the value of newly eligible assets considerably increased after the relaxation of collateral criteria in October and November 2008 and it also remained on a high level throughout 2012.

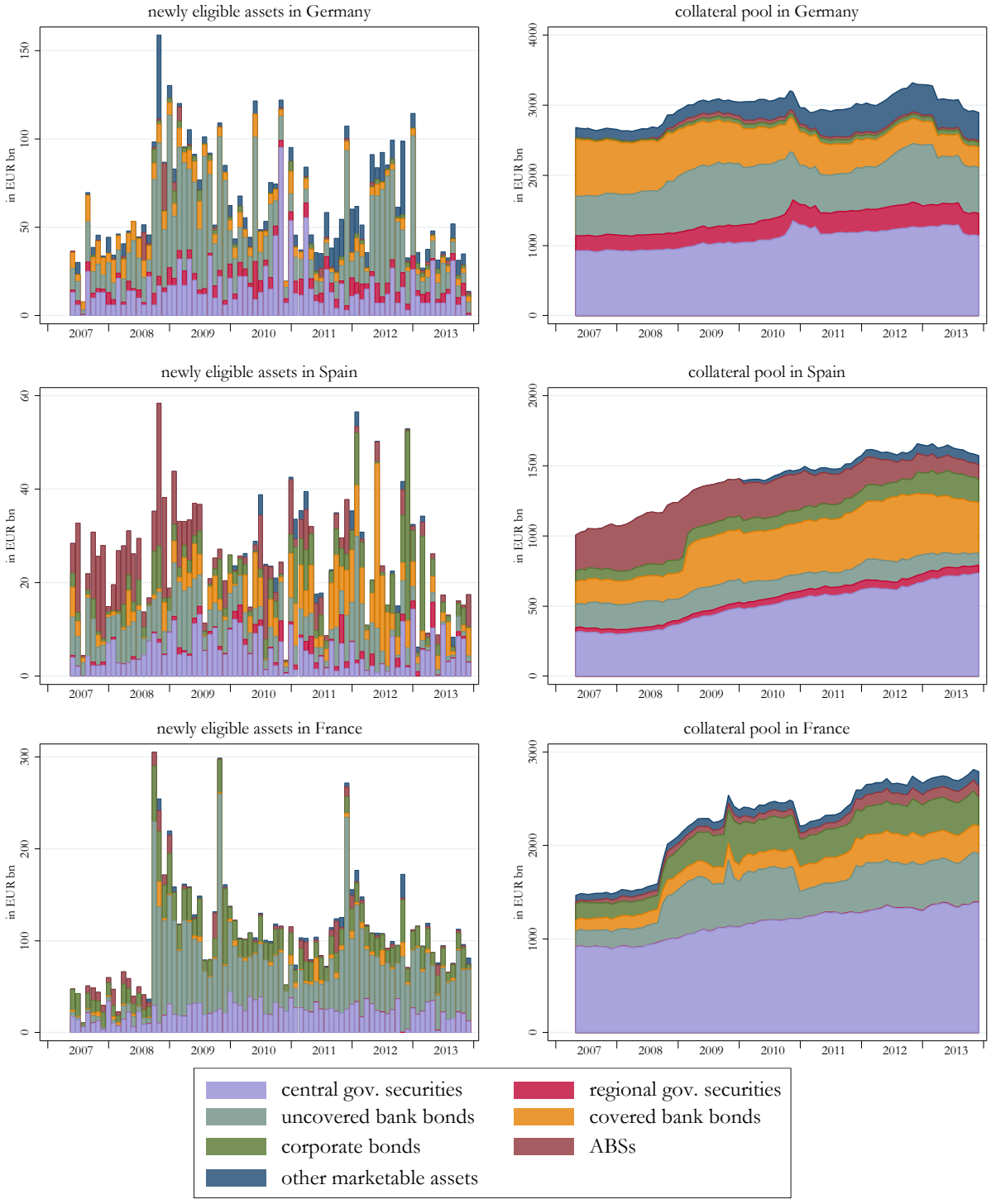
The Spanish collateral pool increased mainly owing to the increase in government bonds. While ABSs played an important role in Spain until February 2009, their value dropped in March 2009 owing to two changes of the collateral framework (see Section 3.2.5), i.e. the tightening of the minimum credit rating for ABSs (to "triple A" at issuance and "single A" over lifetime) and the ineligibility of ABSs comprising tranches of other ABSs. This development is also reflected in the value of newly eligible ABSs, which was high prior to 2009 but covered and uncovered bank bonds as well as corporate bonds became newly eligible assets thereafter. Hence, the drop in ABSs was compensated by increases in bank and corporate bonds.

In France, the collateral pool increased over time, mainly attributed to increases in the amount of government bonds and uncovered bank bonds. The increase in uncovered bank bonds was largely due to the eligibility of bank bonds traded on non-regulated markets from October 2008 to December 2010 and as of January 2012. This is also reflected in the development of newly eligible assets, which largely comprised uncovered bank bonds.

The Greek collateral pool almost exclusively comprised government bonds until mid-2010. Since the outbreak of the sovereign debt crisis in May 2010, the value of eligible government bonds stabilized and uncovered bank bonds gained in importance (albeit largely guaranteed by the Greek government, cf. Chapter 8). The Greek collateral pool diminished in 2012 when the Eurosystem revoked the suspension of the minimum credit rating threshold for bonds issued or guaranteed by the Greek government in February. In March 2012, the suspension was reintroduced, albeit conditional upon the provision of a buy-back scheme (cf. Section 3.2.2). When Greek government bonds were deemed ineligible even if a buy-back scheme was provided as of

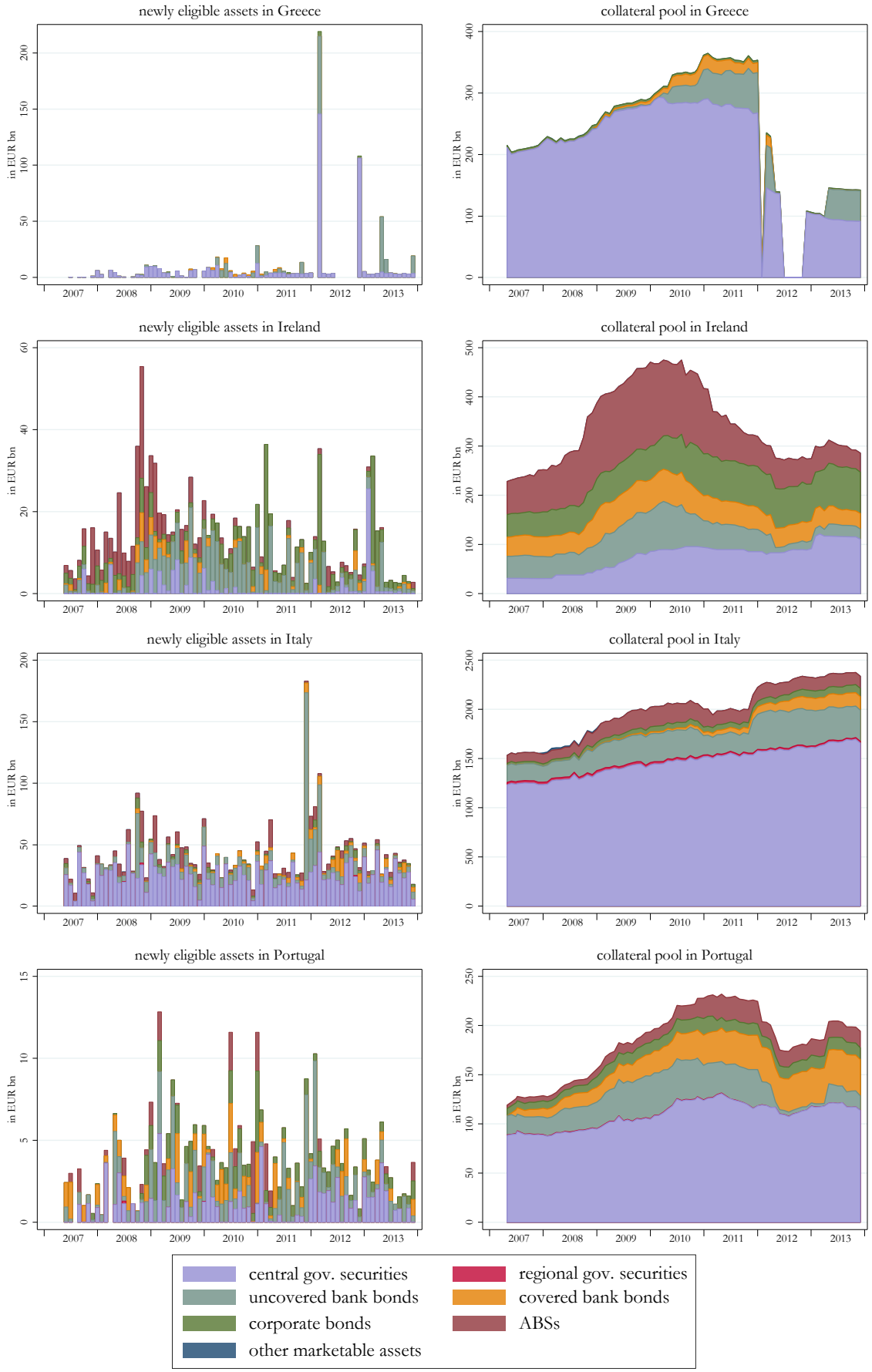
Figure 3.13: Newly eligible marketable assets & national collateral pools by asset type

The figure analyzes newly eligible marketable assets by asset type in selected countries (left panels) together with their effect on national collateral pools (right panels) from 2007 to 2013. It shows that national collateral pools grew, largely owing to increases in newly eligible government bonds and uncovered bank bonds. ABSs lost in importance in most countries and covered bank bonds played only a minor role, aside from in Spain.



Source: author's calculation; European Central Bank, *Eligible Assets Database*.

Figure 3.13: Newly eligible marketable assets & national collateral pools by asset type (cont.)



Source: author's calculation; European Central Bank, *Eligible Assets Database*.

July 2012, the Greek collateral pool fully drained. Ineligibility lasted until December 2012 when the minimum credit rating threshold was again waived. Changes to eligibility are also reflected in the development of newly eligible assets, indicating two spikes in newly eligible government bonds. The first spike coincides with the introduction of the conditional suspension of the minimum rating in March 2012 and the second with the reintroduced unconditional suspension in December 2012. Interestingly, the Eligible Assets Database indicates that the Greek collateral pool was empty between July and November 2012 although only bonds issued or guaranteed by the Greek government were subject to changes in collateral criteria.

The Italian collateral pool increased over time as inter alia the value of newly eligible uncovered bank bonds rose, although this is largely attributed to newly eligible government bonds. The value of newly eligible government bonds remained high and occasional increases in the value of newly eligible uncovered bank bonds caused spikes in the value of newly eligible marketable assets.

Likewise, the collateral pool grew in Portugal from May 2007 to December 2013, albeit with a dint from May 2012 to April 2013 coinciding with the release of the NCBs' obligation to accept eligible government-guaranteed bank bonds provided that the guarantor is a country under an EU/IMF program or whose credit assessment does not meet high credit standards (cf. Section 3.2.4). However, the development of newly eligible collateral indicates that the dint was largely caused by fewer newly eligible uncovered bank bonds. While these bonds became newly eligible to a large extent after the onset of the financial crisis, the value of newly eligible uncovered bank bonds remained low from May 2012 to April 2013. This lack of uncovered bank bonds was compensated by newly eligible government bonds.

In Ireland, the collateral pool substantially expanded by the end of 2010, largely driven by newly eligible ABSs. Newly eligible ABSs thereafter almost came to a halt and the pool shrunk until May 2012. Interestingly, although the Eurosystem suspended the minimum credit rating for Irish government bonds as of April 2011, no such bond became newly eligible from April 2011 to January 2012. The lack of government bonds and ABSs was compensated by newly eligible corporate and uncovered bank bonds, with the latter being largely guaranteed by the Irish government (cf. Chapter 8).

In summary, Figure 3.13 provides new information on the development and composition by asset type of newly eligible marketable assets and national collateral pools, revealing two important findings. First, national collateral pools substantially grew from 2007 to 2013, whereby this growth differed across countries. Growth was largely due to increases in newly eligible government bonds and uncovered bank bonds. Accordingly, this implies, as a second finding, that the composition of newly eligible marketable assets and hence national collateral pools by asset type substantially differed across countries.

3.3.4 Credit Quality of Eligible Marketable Assets

The descriptive analysis thus far has made no distinction between the horizontal and vertical broadening of the collateral pool. However, Section 3.2.7 summarized that this distinction is

important given that the Eurosystem amended the collateral framework to broaden the collateral pool along both dimensions. Therefore, the following investigation extends the analysis and elaborates on the distinction between horizontal and vertical broadening of the collateral pool by analyzing the credit quality of newly eligible marketable assets and the collateral pool (both total and national). Hence, it resembles the previous analysis yet differentiates by the credit quality of eligible assets rather than asset types.

While the previous analysis refined (composition of the collateral pool by asset type) and extended available information (analysis at the country level), this section provides innovative insights as the Eligible Assets Database does not contain information on credit quality. Three procedures are possible to gain insights into the development of credit quality of eligible assets. First, the development of the average haircut applied to eligible assets can be used as a proxy for credit quality. However, Chapter 4 indicates that this proxy would be flawed as haircuts are subject to exogenous changes (irrespective of credit quality), which would affect the average haircut detached from credit quality. Second, credit assessments from rating agencies could be obtained, although this procedure proves impracticable as neither are all assets rated by rating agencies nor is there a historical record on credit ratings available. Therefore, a third approach is elaborated that combines information provided in the Eligible Assets Database and a self-compiled comprehensive database of haircuts applied by the Eurosystem from 2007 to 2013 (see also Chapter 4). The application of this inductive identification strategy provides the first outside-in analysis of credit quality of marketable assets eligible with the Eurosystem in refinancing operations between 2007 and 2013.[122] Chapter 4 addresses that the Eurosystem essentially determines haircuts based on four factors: *(i)* liquidity, *(ii)* coupon, *(iii)* residual maturity and *(iv)* credit quality.[123] Taking advantage of information on the first three factors provided in the Eligible Assets Database, *credit quality* is inferred as the missing fourth factor from information on haircuts contained in the self-compiled database. Therefore, the analysis derives the Eurosystem's understanding of credit quality in terms of the credit quality of collateral clustered into CQSs, thereby providing new insights into the credit quality of eligible marketable assets.

The left panel of Figure 3.14 details the credit quality of newly eligible marketable assets, while the right panel shows the development of credit quality in the collateral pool. The green area represents assets in CQS 1/2, i.e. assets rated between "triple A" and "single A". As "single A" was the initial minimum credit rating threshold, the green area reflects the *horizontal* broadening of the collateral pool. By contrast, the red and blue areas represent the *vertical* broadening as the red area gives all assets within CQS 3 (i.e. lower than "single A" and at least "triple B") and the blue area shows assets rated lower than "triple B".[124] Therefore, the two areas jointly measure additional assets made available by lowering or waiving the minimum credit rating

[122] About 99% of eligible marketable assets could be unanimously matched over the entire time horizon by this technique. No more than 5% of assets could not be matched at each point in time.

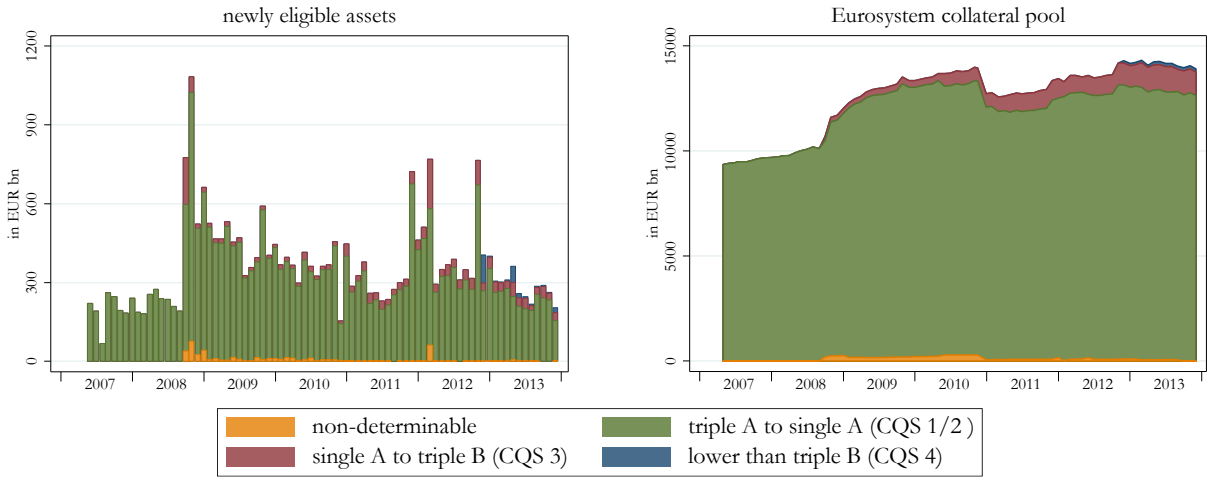
[123] Moreover, supplementary haircuts on e.g. foreign currency assets are applied (cf. Section 4.2.3.2).

[124] Collateral rated lower than "triple B" was only deemed eligible in case of specific government-related assets for which the credit rating requirement was waived or within the ACCs framework (cf. Section 3.2.2). In case of ACCs, these assets are referred to as CQS 4 with a default probability of up to 1.0%, see e.g. Maharaj et al. 2012. As only eligible marketable assets are considered here, credit claims are not reflected in the figures.

threshold.[125] The figure reveals that collateral rated lower than the initial rating threshold steadily rose from October 2008 to December 2013 and particularly following the onset of the sovereign debt crisis in 2010. Hence, it suggests that the broadening of the collateral pool was achieved both horizontally and vertically.

Figure 3.14: Newly eligible marketable assets and the collateral pool by credit quality

The figure illustrates the development of credit quality of newly eligible marketable assets (left panel) and the Eurosystem collateral pool (right panel). The figure indicates the horizontal and vertical broadening of the collateral pool (Section 3.2.7). Credit quality deteriorated particularly following the onset of the sovereign debt crisis in 2010.



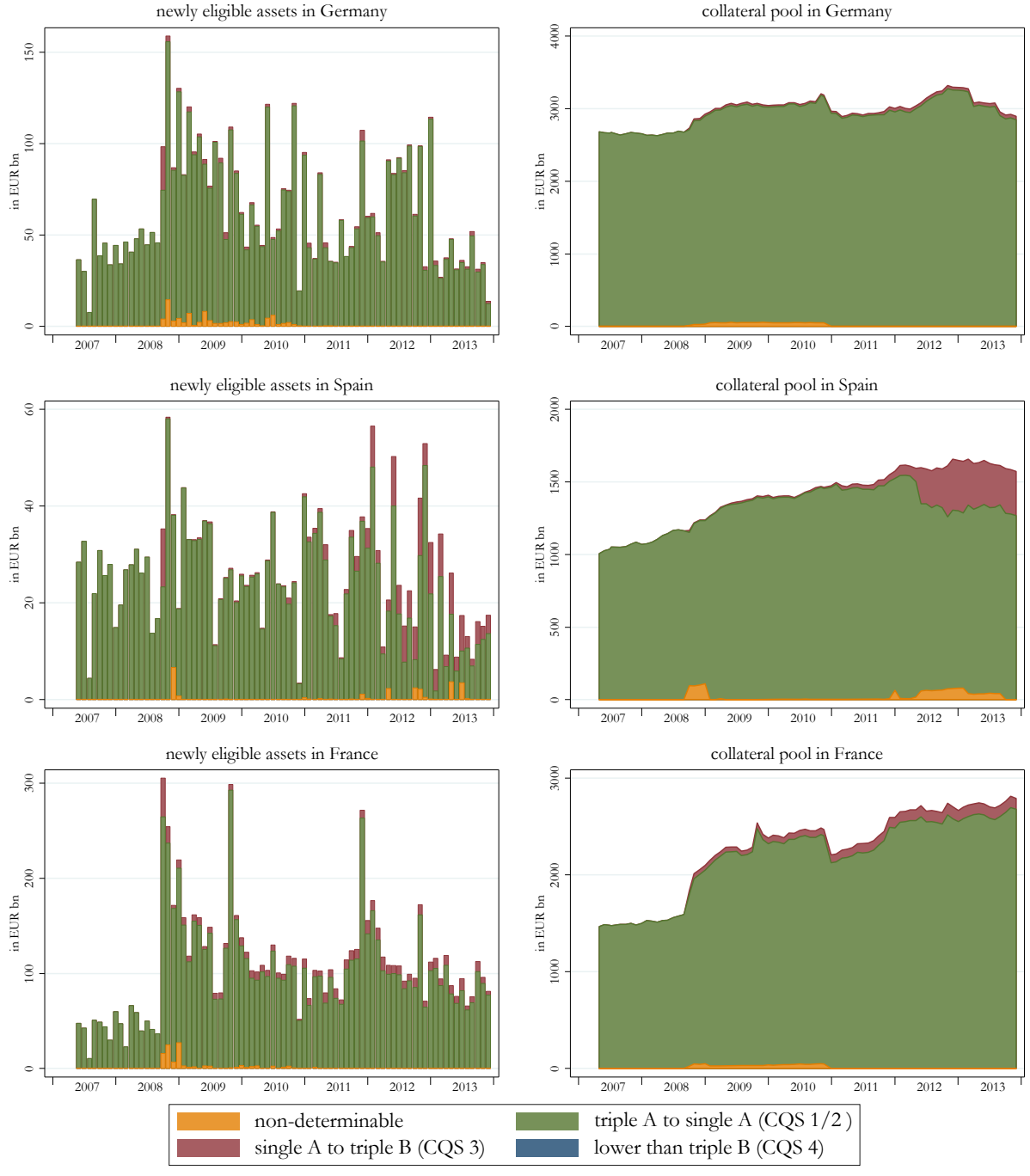
Source: author's calculation; European Central Bank, *Eligible Assets Database*.

The finding that the broadening was achieved both horizontally and vertically only partly holds for national collateral pools in Germany and France, which are inter alia depicted in Figure 3.15, illustrating the development of credit quality of newly eligible marketable assets and national collateral pools. The credit quality of eligible marketable assets remained high in Germany, where collateral was almost exclusively rated within CQS 1/2. A similar development is observable for France, although small fractions of newly eligible assets were rated within CQS 3 immediately after the onset of the financial crisis and throughout the sovereign debt crisis. National collateral pools were considerably broadened vertically in Ireland, Spain and Italy. While the credit quality of eligible marketable assets already dropped throughout the financial crisis in Ireland, deterioration was delayed in Spain and Italy, where credit quality worsened at the turn of 2011/2012. Credit quality declined the most in Greece and Portugal. In Portugal, deterioration commenced when the sovereign debt crisis set in and it further intensified such that the majority of collateral was rated within CQS 3 at the end of 2013. Likewise, collateral quality substantially dropped in Greece with the onset of the sovereign debt crisis and it did not recover thereafter. At the end of 2013, eligible marketable assets in Greece were exclusively of credit quality lower than "triple B" (CQS 4). Hence, no marketable assets would have been eligible in Greece at the end of 2013 if the Eurosystem had not waived the rating requirement for government-related assets.

[125] The yellow area represents the small fraction of assets that could not be inferred to a CQS.

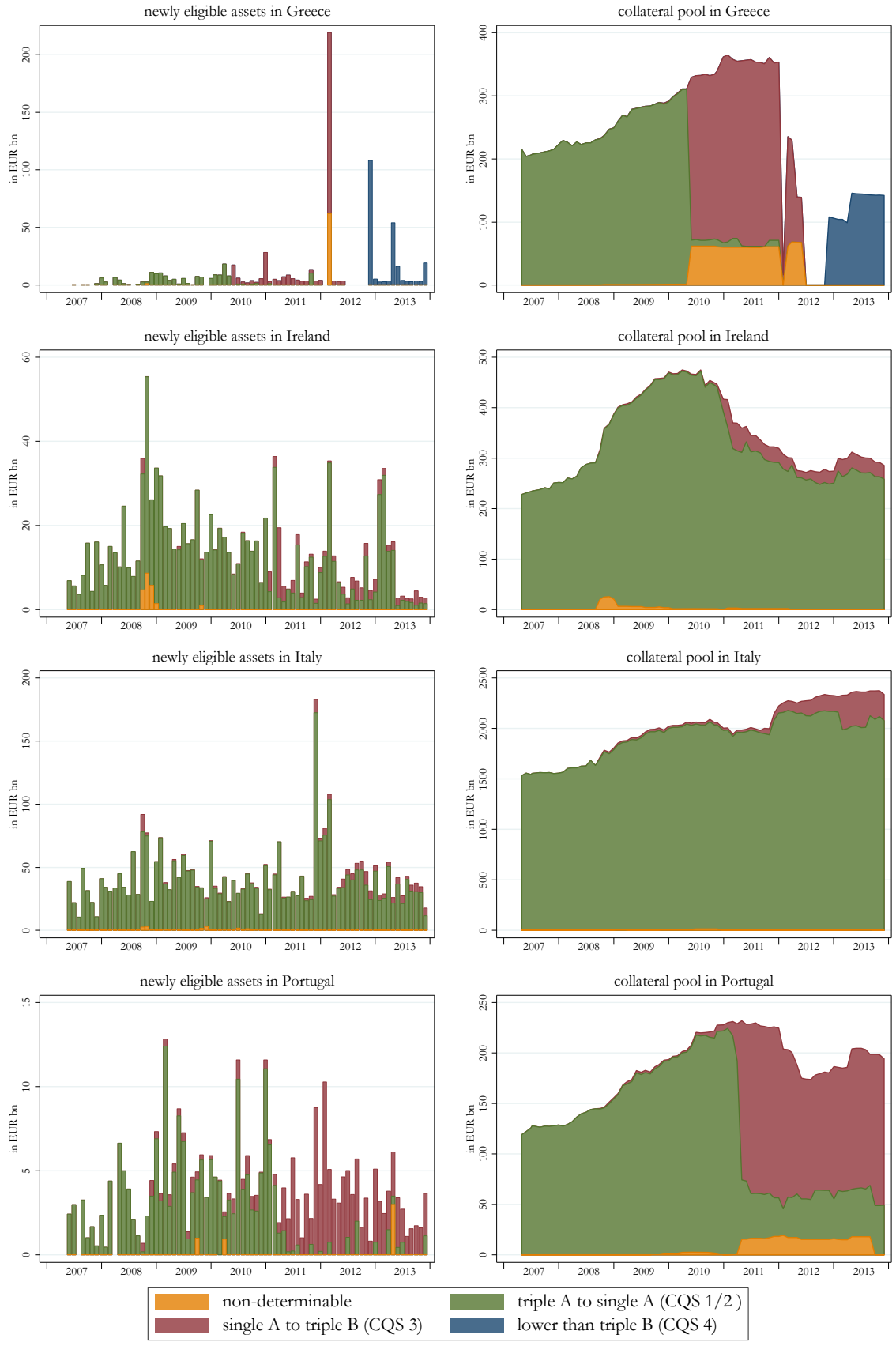
Figure 3.15: Newly elig. marketable assets & national collateral pools by credit quality

The figure depicts the development of credit quality of newly eligible marketable assets (left panels) and national collateral pools (right panels). The credit quality of eligible marketable assets remained high in Germany and France where national collateral pools were hence predominantly broadened horizontally. By contrast, national collateral pools were broadened vertically to a considerable extent in Ireland, Spain and Italy. The credit quality of eligible marketable assets deteriorated the most in Greece and Portugal.



Source: author's calculation; European Central Bank, *Eligible Assets Database*.

Figure 3.15: Newly elig. marketable assets & national collateral pools by credit quality (cont.)



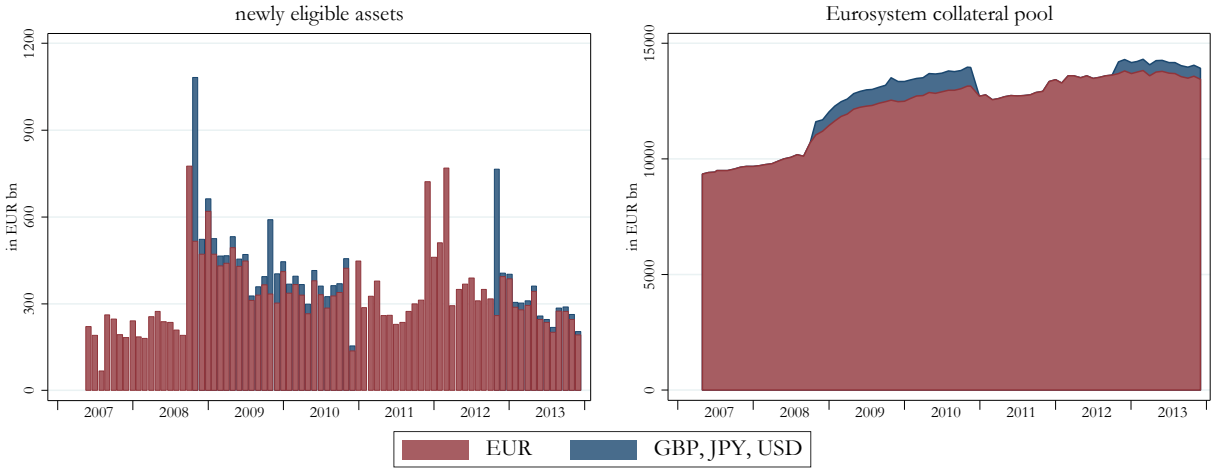
Source: author's calculation; European Central Bank, *Eligible Assets Database*.

3.3.5 Denomination of Eligible Marketable Assets

An amendment to the collateral framework that is often considered important to the broadening of the collateral pool was the eligibility of marketable assets denominated in certain foreign currencies, i.e. pounds sterling, yen and US dollars. Such assets were made eligible in two phases (see Section 3.2.1.2): *(i)* from November 2008 to December 2010 and *(ii)* as of November 2012. These two phases are also apparent in Figure 3.16, which details the development of newly eligible marketable assets (left panel) and the collateral pool (right panel) by denomination. The figure reveals that the eligibility of foreign currency assets contributed to broadening the collateral pool, particularly following the onset of the financial crisis in the fall of 2008 and with renewed eligibility in November 2012.

Figure 3.16: Newly eligible marketable assets and the collateral pool by denomination

The figure elaborates on the development of newly eligible collateral (left panel) and the collateral pool (right panel) by denomination from 2007 to 2013. It differentiates between eligible marketable assets denominated in EUR and foreign currencies (GBP, JPY, USD). The panels reveal that the eligibility of foreign currency assets contributed to broadening the collateral pool, with the eligibility introduced in the fall of 2008 and after the renewed eligibility in November 2012.



Source: author's calculation; European Central Bank, *Eligible Assets Database*.

3.3.6 Non-Regulated Markets and Eligible Marketable Assets

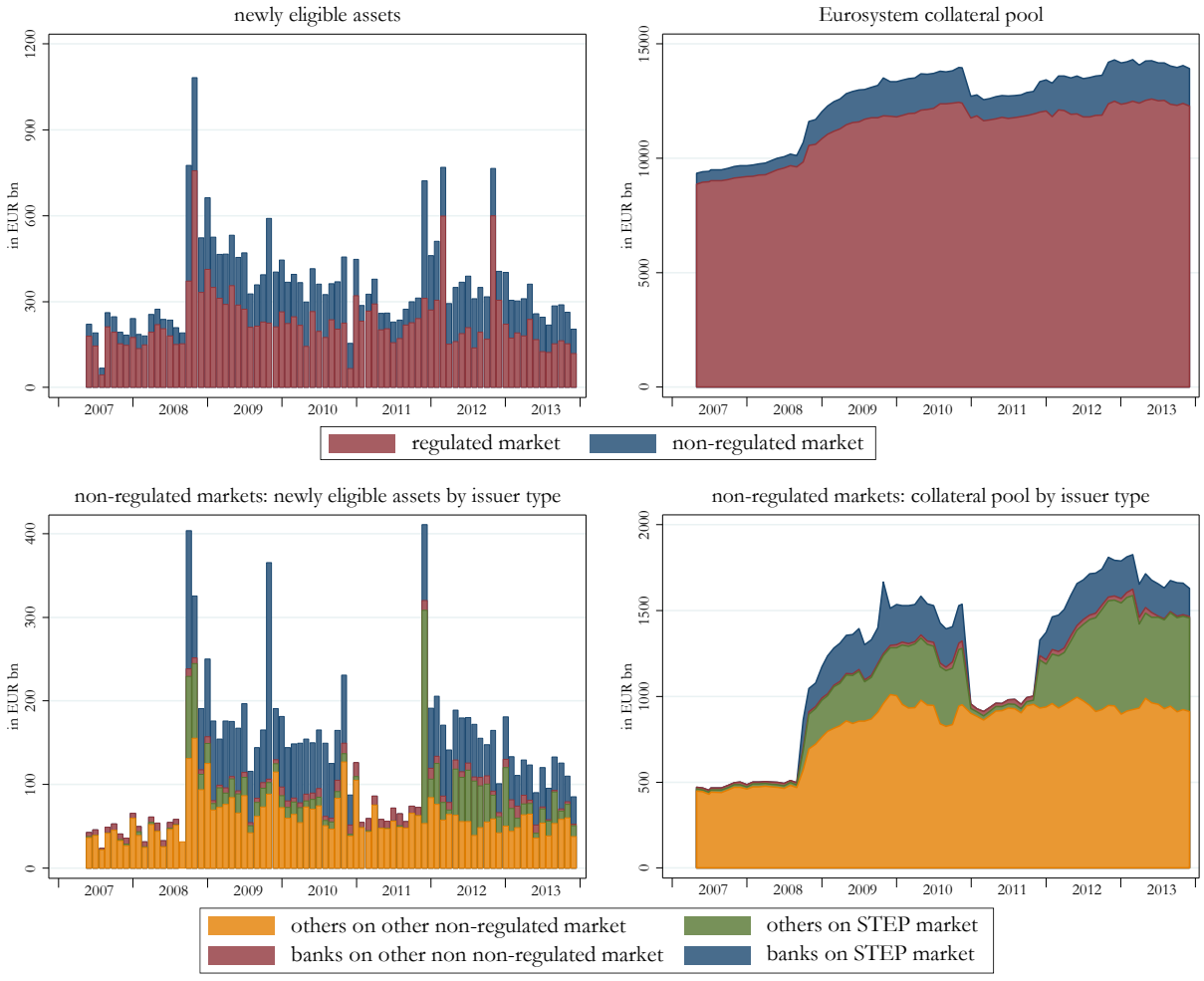
The Eurosystem amended the collateral criteria of assets traded on non-regulated markets by *(i)* increasing the number of accepted non-regulated markets and *(ii)* deeming eligible additional asset types traded on accepted non-regulated markets (cf. Section 3.2.3). The upper panels in Figure 3.17 indicate that the Eurosystem succeeded in broadening the collateral pool, especially after the turmoil in financial markets in the fall of 2008. The upper left panel considers newly eligible marketable assets and differentiates between assets traded on non-regulated and regulated markets. It reveals that a substantial fraction of newly eligible assets were traded on accepted non-regulated markets. In particular, this fraction increased after bank bonds traded on non-regulated markets were deemed eligible as of October 2008.

The upper right panel illustrates that the increase in newly eligible assets traded on non-regulated markets affected the composition of the collateral pool as the fraction of assets traded

on non-regulated markets increased over time. The lower panels seize upon the important role of the STEP market (see Section 3.2.3) and investigate the blue areas in the upper panels, i.e. they focus on newly (left panel) and total eligible marketable assets (right panel) traded on non-regulated markets. They differentiate between assets issued on the STEP market (by banks or by others) and other non-regulated markets (by banks or by others), confirming that the increase of eligible assets traded on non-regulated markets was largely due to the eligibility of bank bonds traded on these markets, especially on the STEP market. Bank bonds traded on non-regulated markets have been eligible during two phases (cf. Section 3.2.3), i.e. in a first phase from October 2008 to December 2010 and as of January 2012. By the end of 2013, almost half of eligible marketable assets traded on non-regulated markets were issued by banks.

Figure 3.17: Newly eligible marketable assets and the collateral pool by type of market

The figure elaborates on the development of the role of eligible assets traded on non-regulated markets in due consideration of the STEP market. The upper panels indicate that the Eurosystem succeeded in broadening the collateral pool by extending the acceptance of non-regulated markets. The lower panels refine the blue areas in the upper panels with due regard to the STEP market. They differentiate between assets issued in the STEP market (by banks or others) and other non-regulated markets (by banks or others). The figure emphasizes the importance of the eligibility of bank bonds traded on non-regulated markets such as the STEP market.



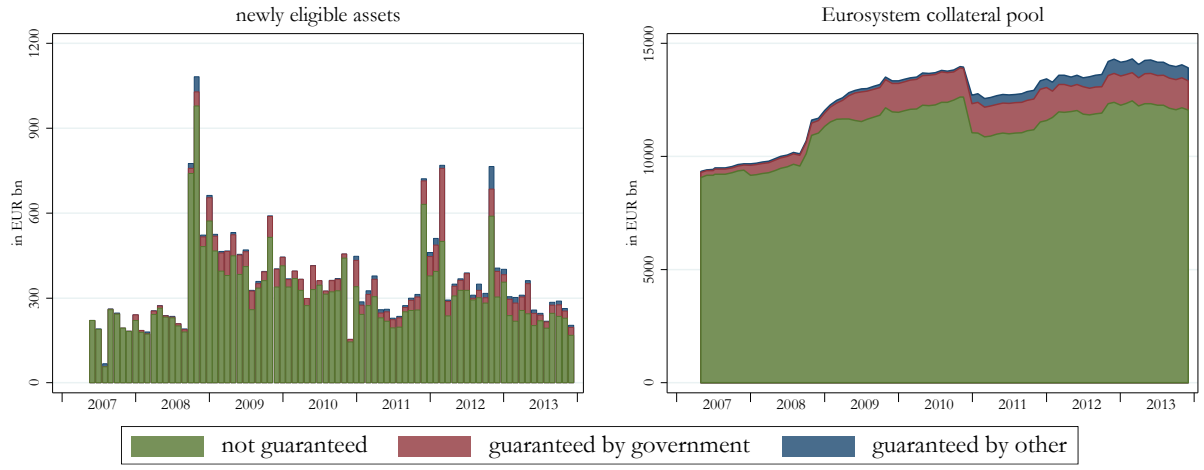
Source: author's calculation; European Central Bank, *Eligible Assets Database*.

3.3.7 Government Guarantees and Eligible Marketable Assets

Section 3.2.2 inter alia discussed how the collateral criteria of government-guaranteed assets were amended. Figure 3.18 suggests that the collateral pool broadened owing to these amendments, particularly following the onset of the financial crisis. The left panel shows newly eligible marketable assets and the right panel illustrates the development of the collateral pool. The panels differentiate between assets that are *(i)* not guaranteed, *(ii)* guaranteed by governments and *(iii)* guaranteed by others (e.g. private sector entities). While the vast majority of eligible marketable assets was not guaranteed, government guarantees increased in importance. Government guarantees to eligible marketable assets are further addressed in Chapter 8, where the development observable in Figure 3.18 is investigated.[126]

Figure 3.18: Newly eligible marketable assets and the collateral pool with respect to guarantees

The figure illustrates the development of newly eligible marketable assets (left panel) and the collateral pool (right panel) with respect to guarantees from 2007 to 2013. It shows that the amount of eligible guaranteed assets increased over time, particularly with government guarantees.



Source: author's calculation; European Central Bank, *Eligible Assets Database*.

3.3.8 Residual Maturity of Eligible Marketable Assets

Finally, the effects of changes to collateral criteria on the residual maturity of eligible marketable assets are scrutinized. Figure 3.19 illustrates the average residual maturity of newly eligible marketable assets as well as in the collateral pool (weighted by nominal value).[127] The figure highlights that the average maturity of newly eligible assets and accordingly in the collateral pool dropped owing to amendments to collateral criteria in October 2008, especially as STEPs issued by banks with per definition short maturity were deemed eligible. Thereafter, the average residual maturity slightly increased but jumped and dropped when STEPs issued by banks were temporarily deemed ineligible throughout 2011. The average residual maturity of newly eligible marketable assets experienced another jump in November 2012 when foreign denominated assets

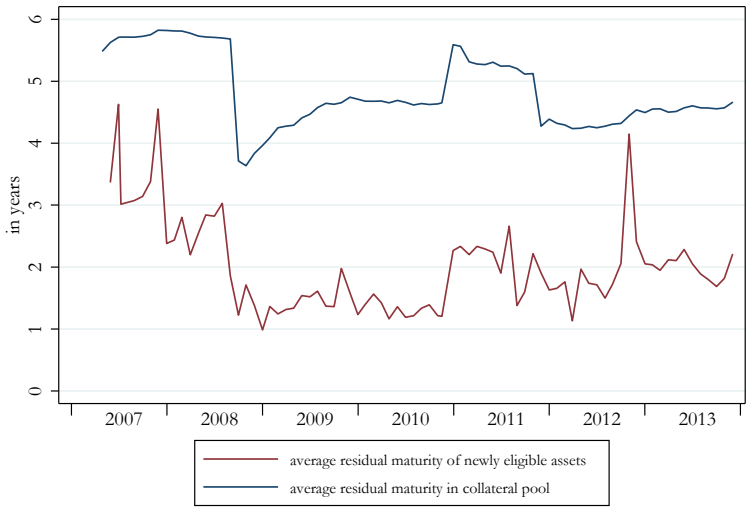
[126] Recently, Nyborg 2015 pointed to the importance government guarantees in the Eurosystem collateral framework, emphasizing that it implies leeway for politics to influence collateral values.

[127] The collateral pool contained 57 government bonds, covered and uncovered bank bonds as well as corporate bonds with 9999 as the year of maturity between May 2007 and January 2013. These assets are neglected as outliers to avoid potential biases in the depiction of average residual maturities.

became eligible again. Hence, the figure reveals that the average residual maturity of newly eligible marketable assets and in the collateral pool fluctuated and decreased over time, inter alia reflecting amendments to collateral criteria. The average residual maturity in the collateral pool decreased from 5.5 years in May 2007 to 4.6 years in December 2013. Observable fluctuations in the average residual maturity of newly eligible marketable assets can be associated with amendments to collateral criteria, specifically *(i)* the eligibility of STEPs issued by banks and *(ii)* the eligibility of assets denominated in certain foreign currencies.

Figure 3.19: Average residual maturity of eligible marketable assets

The figure illustrates the average residual maturity of newly eligible marketable assets and in the Eurosystem collateral pool. It highlights that the average residual maturity of newly eligible assets considerably fluctuated, reflecting amendments to collateral criteria. The average maturity in the collateral pool decreased from 5.5 years in May 2007 to 4.6 years in December 2013.



Source: author's calculation; European Central Bank, *Eligible Assets Database*.

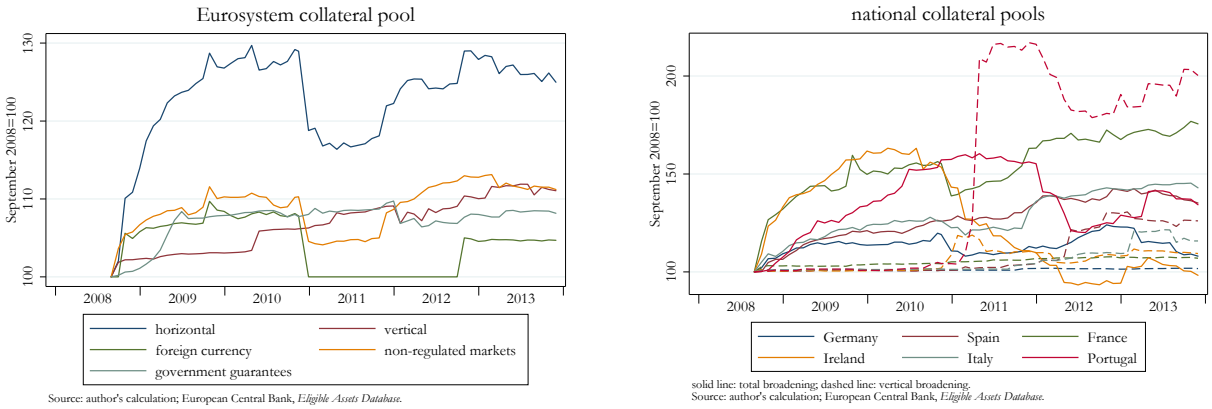
3.3.9 Lessons from Analyzing the Collateral Pool Development

In conclusion, this section has revealed that the Eurosystem collateral pool has changed in both size and composition over recent years, reflecting amendments to collateral criteria. The Eurosystem broadened the collateral pool both horizontally and vertically by deeming more asset types eligible, as well as assets of lower credit quality. Moreover, it extended eligibility to assets denominated in certain foreign currencies, amplified the eligibility of assets traded on non-regulated markets and relaxed the collateral criteria of government-guaranteed assets.

The extent to which these measures broadened the Eurosystem collateral pool are reflected in the left panel of Figure 3.20. The size of the collateral pool in September 2008 is normalized to 100 to capture the effects of amendments to the collateral framework. The left panel reveals that the most important measures of the Eurosystem were to deem more assets of initial credit quality eligible ("horizontal"), relax the collateral criteria of assets traded on non-regulated markets and deem eligible more assets of lower credit quality ("vertical"). Moreover, the extended eligibility of government-guaranteed assets as well as assets denominated in foreign currency contributed to the broadening of the Eurosystem collateral pool.

Figure 3.20: Broadening of the Eurosystem collateral pool and national collateral pools

The figure shows the broadening of the Eurosystem collateral pool (left panel) and national collateral pools (right panel) from 2007 to 2013. Pool size is normalized to 100 for pre-crisis sizes in September 2008. The left panel takes up broadening measures and suggests that quantitative was more important than qualitative broadening. Moreover, the extended eligibility of assets traded in non-regulated markets, government-guaranteed assets and assets denominated in foreign currency contributed to the broadening. The right panel seizes upon the broadening of national collateral pools and details total (solid line) and vertical broadening (dashed line). It shows that broadening was the strongest in France, Italy, Spain and Portugal but modest in Germany and even negative in Ireland. Vertical broadening was minor in Germany, France and Ireland but important in Italy and Spain. It was negligible in Portugal prior to 2011 but exploded thereafter.



Source: author's calculation; European Central Bank, *Eligible Assets Database*.

solid line: total broadening; dashed line: vertical broadening.
Source: author's calculation; European Central Bank, *Eligible Assets Database*.

Furthermore, the geographical composition of the collateral pool changed owing to asymmetric developments of national collateral pools, as shown in the right panel of Figure 3.20 for selected countries. The size of national collateral pools in September 2008 is again normalized to 100. Solid lines refer to the development of national collateral pools and dashed lines detail the extent of their vertical broadening. The panel confirms that national collateral pools grew the strongest in France, Italy, Spain and Portugal (in that order) from 2007 to 2013. The national collateral pool only slightly increased in Germany and it even shrunk in Ireland, although the Irish collateral pool exhibited the largest expansion during the financial crisis until the onset of the sovereign debt crisis. Vertical broadening of national collateral pools was modest in Germany, France and Ireland but stronger in Italy and Spain. It was minor in Portugal prior to 2011 but exploded thereafter, thus confirming the finding of Figure 3.15 that credit quality in the Portuguese collateral pool dropped in 2011. Hence, the Portuguese collateral pool was not only qualitatively broadened but also a fraction of the collateral pool was qualitatively replaced, i.e. assets within CQS 1/2 were replaced by assets within CQS 3.

4

Risk Control of the Eurosystem[128]

The Eurosystem is exposed to two types of risk in its credit operations. Counterparties can default on their loans, which gives rise to (i) counterparty risk. Despite requiring counterparties to be supervised and deemed financially sound, the Eurosystem hedges counterparty risk by calling for collateral. Therefore, the Eurosystem can liquidate collateral to meet its claims in case of counterparty default. However, the assumption of collateral exposes the Eurosystem to (ii) collateral risk as the liquidation value of collateral is uncertain at the time when the loan is contracted. The Eurosystem applies a set of measures to mitigate collateral risk that are laid down in its collateral framework. Accordingly, this chapter explores the application and development of these risk control measures. It shows that the Eurosystem specifies risk control in a simplified fashion based on a reduced set of available information, which implies imperfect mitigation of collateral risk. The previous chapter revealed that the collateral pool has evolved along various dimensions over recent years, inter alia owing to amendments to the collateral framework. This chapter addresses how the Eurosystem accommodated risk control in response to its changing collateral pool. First, Section 4.1 provides an overview of risk control measures of the Eurosystem and identifies haircuts as the most important measure. Section 4.2 elaborates on haircuts. It derives general principles for their specification, compiles a narrative database of Eurosystem haircuts and provides a descriptive analysis of their evolution. Subsequently, Section 4.3 evaluates the specification of Eurosystem haircuts against the derived general principles and carves out its shortcomings. Finally, the potential effects of the shortcomings are addressed in Section 4.4.

[128] This chapter bases on Eberl and Weber 2014b.

4.1 The Set of Risk Control Measures

The Eurosystem hedges risk from collateralized lending in two steps.[129] First, it requires counterparties to obey the minimum reserve requirement, be supervised and deemed financially sound (see ECB 2015c). Second, it calls for adequate collateralization of provided liquidity. Accordingly, the Eurosystem is exposed to collateral risk as the liquidation value of collateral is uncertain at the time when the loan is contracted. The Eurosystem applies a set of measures to mitigate collateral risk, which are summarized in Table 4.1 (see also ECB 2000, 2011d, 2015c).[130]

Prior to the introduction of the Single List in January 2007, the Eurosystem established uniform risk control measures for tier 1 assets and NCBs were responsible for taking control for assets that they accepted in tier 2. The initial set of risk control measures comprised "valuation haircuts", "initial margins", "variation margins", "limits in relation to issuers/debtors or guarantors", "additional guarantees" and "exclusion". The Eurosystem restricted the set of disposable risk control measures to "valuation haircuts" and "variation margins" in March 2004. It announced to perform a biennial review of its risk control measures in 2008 in response to amendments to the collateral framework and developments in financial markets. Since then, valuation haircuts have been repeatedly updated (see next section) and partly adapted to collateral pool and market developments. Moreover, the Eurosystem revoked its restriction of the set of risk control measures in February 2009 such that all risk control measures could be applied "at any time if required to ensure adequate risk protection" (cf. ECB 2008b, p. 37). The Eurosystem successively introduced two additional means to address collateral risk in February and March 2009, i.e. "supplementary haircuts" and "limits in relation to the use of uncovered bank bonds".[131] The latter measure has quantitatively limited the use of uncovered bank bonds with close links that were deemed eligible if they were guaranteed by a government (see Section 3.2.4). Hence, uncovered bank bonds of the same issuer group (i.e. identical issuer or closely linked issuers) could only be pledged to the extent that the haircut-adjusted value of these bonds would not exceed 10% (later 5%) of the total value of collateral submitted by a counterparty as of March 2009. This limitation was generalized to unsecured debt instruments with close links in October 2010 and explicitly added to the set of risk control measures. The implementation of the ACCs framework in December 2011 enabled NCBs to establish idiosyncratic risk control measures that could deviate from those applied within the collateral framework. The application of idiosyncratic risk control measures was made subject to approval of the Governing Council. This approval was considered unnecessary in exceptional circumstances as of May 2013 under the provision that the risk control measures would have been established by another NCB and approved by the Council.

Valuation haircuts and variation margins are the only risk control measures applied from January 2001 to December 2014. Valuation haircuts imply that the market or a theoretical value assigned to an eligible asset is deducted by a fraction ("haircut") to determine the collateral

[129] The analysis in this chapter elaborates on risk control in collateralized lending. While asset purchases and collateralized loans share many types of risk, there are important differences (ECB 2015c). Most importantly, the Eurosystem is exposed to potential losses from collateralized lending only in case of double default (i.e. counterparty and collateral default), although it might already suffer losses from asset purchases in case of

Table 4.1: Eurosystem risk control measures

The table provides an overview of the risk control measures applied by the Eurosystem. Valuation haircuts and variation margins are the most important measures and they were applied over the entire period.

Measure	Description	Application Period
Valuation Haircuts	The collateral value is calculated as some value of the asset less a certain percentage (haircut).	01/2001 - present[a]
Supplementary Haircuts	Haircuts that are applied beyond valuation haircuts if considered necessary.	10/2008 - present[a,b]
Initial Margins	Counterparties have to pledge collateral at least equal to liquidity plus the value of the initial margin.	01/2001 - 03/2004; 02/2009 - present[a]
Variation Margins (Marking to Market)	The haircut-adjusted value of collateral has to be maintained over time and if it falls below a threshold, the Eurosystem calls for additional collateral.	01/2001 - present[a]
Limits in Relation to Use of Unsec. Debt Instruments	Limitation of the pledge of unsecured debt instruments with close links as described in Section 3.2.4.	03/2009 - present[a,c]
Limits in Relation to Issuers/Debtors/Guarantors	Limitation of the exposure vis-à-vis issuers/debtors/guarantors in general or vis-à-vis specific counterparties.	01/2001 - 03/2004; 02/2009 - present[a]
Additional Guarantees	Additional guarantees can be required from counterparties to accept certain assets as collateral.	01/2001 - 03/2004; 02/2009 - present[a]
Exclusion	Certain assets and/or counterparties can be excluded.	01/2001 - 03/2004; 02/2009 - present[a]

[a] By the end of 2014.
[b] The Eurosystem applied supplementary haircuts to e.g. assets within CQS 3 since October 2008. Supplementary haircuts for risk control were mentioned in February 2009 in the collateral framework. They were explicitly included as a risk control measure in October 2010.
[c] The measure was first specified for uncovered bank bonds in March 2009 and generalized to unsecured debt instruments in October 2010.
Source: author's compilation; European Central Bank.

value. Valuation haircuts reflect expectations about the liquidation value of collateral in case of counterparty default. Variation margins subsequently ensure that this expected liquidation value is maintained over time. Amendments to the collateral framework making eligible more types of assets of different credit quality called for repeated adjustments to valuation haircuts, thus rendering them key to Eurosystem risk control (see also ECB 2015c).

4.2 Haircuts as the Key Risk Control Measure

The analysis of valuation haircuts as the key risk control measure of the Eurosystem is important for two reasons. First, haircuts are applied as a discount to the value of an eligible asset

single default (i.e. collateral default). Therefore, risk control differs between collateralized lending and asset purchases. See European Central Bank 2015c for an in-depth investigation.

[130] See Bindseil et al. 2009 (in particular Bindseil 2009a, Bindseil and Papadia 2009, González and Molitor 2009, Tabakis and Weller 2009) as well as Chailloux et al. 2008b for general discussions and contributions to central bank risk mitigation.

[131] "Supplementary haircuts" were explicitly introduced as a risk control measure in October 2010, see Table 4.1.

such that they determine the amount of liquidity that the Eurosystem supplies for eligible assets. Therefore, the haircut is one of the six determinants of credit terms (see Section 2.3). Second, some central (clearing) counterparties (CCPs) adopt haircuts of the Eurosystem such that Eurosystem haircuts not only influence refinancing conditions with the Eurosystem but they also spill over to the interbank repo market (see Section 5.2.2 and Nyborg 2015).[132]

There is relatively little work on haircut-setting within collateral frameworks of central banks. Jokivuolle and Peura 2000 provide an investigation of central bank haircuts on bank loans and Ashcraft et al. 2011 analyze the role of haircuts in collateralized central banks loans. ECB 2014a has recently extended ECB 2013a and presents insights into the role of haircuts within the Eurosystem collateral framework, comparing haircut ranges of the Eurosystem with the CCP-cleared segment of the repo market. Moreover, ECB 2015c emphasizes the role of haircuts in Eurosystem risk control and provides a sketchy overview of their development.

The value of a collateral asset is adjusted for risk control purposes by either *(i)* a haircut or *(ii)* an initial margin. For a haircut, a discount on some value of the collateral (e.g. the market value) is taken such that the asset's collateral value Φ is given by[133]

$$\Phi \equiv (1-h)\Omega, \tag{4.1}$$

with h being the haircut and Ω the market value of the asset. The haircut can be expressed as

$$h = \frac{\Omega - \Phi}{\Omega}. \tag{4.2}$$

For an initial margin, the loan is over-collateralized by the amount of the initial margin m such that Φ reads as

$$\Phi \equiv \frac{\Omega}{1+m} \tag{4.3}$$

and the initial margin can be calculated as

$$m = \frac{\Omega - \Phi}{\Phi}. \tag{4.4}$$

The difference between a haircut and initial margin is only conceptual as both instruments have equivalent effects. Using Equations (4.1) and (4.3), the relation between a haircut and initial margin can be expressed as[134]

$$h = \frac{m}{1+m}. \tag{4.5}$$

Owing to their importance in the risk control of the Eurosystem, the focus lies on haircuts in the following.

[132] See e.g. Mancini et al. 2015 for the relation between Eurosystem and Eurex haircuts. BIS 1999 provides an early description of the interbank repo market from the perspective of central banks. For further discussion on repo markets and their connection to the Eurosystem's refinancing operations, see Chapter 5. For the European interbank repo market, see Dunne et al. 2011, ECB 2014d as well as Mancini et al. 2015.

[133] For the general characterization of haircuts see also e.g. Choudhry 2006, Euroclear 2009, Comotto 2012, 2013.

[134] For instance, a haircut of 5% would be approximated by an initial margin of 5.26%.

4.2.1 General Principles of the Haircut Specification

Lenders bear different risks in collateralized liquidity provision despite collateralization. They aim to minimize these risks and gain compensation for any remaining. This can be achieved by the application of two instruments, i.e. *(i)* the interest rate and *(ii)* the haircut.[135] The following discussion elaborates on the major risks in collateralized liquidity provision and emphasizes the relevant instrument to address these risks. Moreover, general principles of haircut specification are carved out.[136]

Risk from collateralized liquidity provision only materializes in case of borrower default. In this case, the lender has to liquidate the collateral to meet outstanding claims (from principal and interest). As this *counterparty risk* is solely associated with the financial soundness of the borrower, it should generally be correlated with interest rates but not with haircuts (cf. Comotto 2012 as well as Dang et al. 2013a). Fitch Ratings 2012 finds an indication for the absence of correlation based on empirical observations, while survey results by BIS 2010 suggest a correlation between counterparty risk and haircuts. Furthermore, Dang et al. 2013a find an indication for effects of counterparty risk on haircuts as they observe that borrowers pledging collateral of the same type and credit rating face different haircuts. However, ibid. attribute this finding to a reason other than counterparty risk, i.e. the risk that lenders face a better informed trader in case of collateral liquidation such that they are not compensated for their outstanding claims.[137] Hence, this risk should be addressed by the haircut.

This reflects the sequence of addressing risk in collateralized liquidity provision, i.e. counterparty and collateral risk. Counterparty risk is addressed by charging an interest rate together with demanding collateral. Collateral risk only materializes in case of counterparty default. If collateral risk was adequately addressed by the haircut, no counterparty risk would have to be mitigated via the haircut. Mitigating counterparty risk through the haircut would subsequently imply an inefficient haircut increase, given that it would curtail liquidity provision (given collateral scarcity).

Consider the simple participation constraint of a risk-neutral lender given by Equation (4.6). Let $(1-p) \in [0,1]$ represent the default probability of the counterparty and $(1-q) \in [0,1]$ the default probability of collateral. The interest rate premium in collateralized lending above the market rate of interest (repo rate) is denoted by $i_L \in [0,1]$, which is assumed to be zero for simplicity such that the interest rate premium equals the interest rate. $h \in [0,1]$ is the haircut on collateral that is assessed at its market value Ω. Collateral that the borrower has at disposal is assumed to be restricted to $\overline{\Omega}$. The lender can decide upon the utilization of available liquidity

[135] Lenders could also restrict the set of potential borrowers, which would correspond to a prohibitively high interest rate. Likewise, lenders could define assets that are deemed ineligible as collateral, which would be equivalent to a haircut of 100%.

[136] See also González and Molitor 2009 for a discussion of central bank haircut specification and Nyborg 2015 for general features of Eurosystem haircuts.

[137] This reasoning is based on an utility-based measure, called information acquisition sensitivity, cf. Dang et al. 2013a,b.

to the amount of $(1-h)\overline{\Omega}$ in either collateralized lending or alternative investment in the market at zero interest. The lender's participation constraint reads as

$$\underbrace{p(1+i_L)(1-h)\overline{\Omega}+(1-p)q\overline{\Omega}}_{\text{expected payoff from collateralized loan}} \quad \stackrel{!}{=} \quad \underbrace{(1-h)\overline{\Omega}.}_{\text{payoff from alternative investment}} \tag{4.6}$$

The left-hand side of Equation (4.6) gives the expected payoff to the lender from entering the collateralized loan. The lender receives principal and interest with probability p. With probability $(1-p)$, the counterparty defaults and the lender receives collateral to the amount of $\overline{\Omega}$, which can be liquidated with probability q.[138] [139] The expected payoff from collateralized lending has to put the lender in the same financial position as alternative investment. Therefore, the expected payoff from the collateralized loan has to equal the liquidity of the lender as the market offers zero interest by assumption. Solving Equation (4.6) for i_L gives the following relationship between the interest rate i_L and the haircut h:

$$i_L = \left(1-\frac{q}{1-h}\right)\left(\frac{1-p}{p}\right). \tag{4.7}$$

If counterparty risk is absent, i.e. $p=1$, i_L is also equal to zero irrespective of collateral risk. However, in reality, lending is associated with counterparty risk, i.e. $p \in (0,1)$. If both the interest rate and the haircut are available for risk mitigation, possible combinations of i_L and h that fulfill the lender's participation constraint are given by the negative and concave relationship between i_L and h implied by Equation (4.7).[140]

Furthermore, consider the case in which only either the interest rate or the haircut is available for the mitigation of (counterparty and collateral) risk. If the haircut h is restricted to zero ($h=0$), the interest rate depends on both counterparty and collateral risk such that $i_L = (1-q)\left(\frac{1-p}{p}\right)$. Counterparty risk affects the interest rate to the extent that collateral risk is present. If the collateral was free of risk, i.e. $q=1$, then the interest rate would also be equal to zero. By contrast, if the interest rate is restricted to zero ($i_L=0$), the haircut solely depends on the default probability of the collateral with $h=1-q$, i.e. the haircut would solely and fully reflect collateral risk. This gives a good approximation of the case of the Eurosystem. The Eurosystem sets a single interest rate as a matter of monetary policy and to eliminate pitfalls from having to differentiate pricing of operations based on counterparty creditworthiness. Therefore, the market interest rate is defined by the Eurosystem and liquidity is provided to a wide range of counterparties with different default probabilities at this interest rate. This calls for the implementation of risk control aimed at achieving the equivalence of collateral risk across eligible assets (see ECB 2015c).

[138] The lender will receive the entire liquidation value $q\overline{\Omega}$ in case of counterparty default only if this liquidation value falls short of principal and interest, i.e. $(1+i_L)(1-h)\overline{\Omega}$. Therefore, Equation (4.6) is subject to the constraint that $q\overline{\Omega} \leq (1+i_L)(1-h)\overline{\Omega}$.

[139] Note that without a loss of generality, collateral risk is analyzed in terms of credit risk only. Therefore, e.g. liquidity risk is neglected. See Section 7.3.1 for the liquidity risk of collateral.

[140] As $\partial i/\partial h < 0$ and $\partial^2 i/\partial h^2 < 0$, concavity suggests that as both a larger interest rate and a larger haircut are costly to the borrower, the optimal solution would be to mitigate risk via either the interest rate or the haircut. A larger interest rate is costly because it lowers the margin for the borrower to the extent that the loan does not pay off. A larger haircut decreases principal as Ω is restricted to $\overline{\Omega}$.

Collateral risk is in principle determined by seven types of risk that could materialize between loan contraction and collateral liquidation,[141] i.e. *(i)* legal risk, *(ii)* operational risk, *(iii)* collateral quality (in terms of credit and liquidity risk), *(iv)* market risk (in terms of traded market and valuation risk), *(v)* interest-rate risk, *(vi)* wrong-way risk and *(vii)* exchange-rate risk. In the following, the effects of the seven properties on the haircut size are stylized and general principles of haircut specification are carved out.

First, the transfer of collateral ownership in case of counterparty default should be legally binding in terms of an easily enforceable written contract. In the absence of such a contract, the lender risks legal challenges and facing competition for collateral with other creditors, which would delay the settlement of outstanding claims. This *legal risk* should be addressed by the use of predefined contracts (Master Agreements), such as the Global Master Repurchase Agreement and the European Master Agreement. Only the lack of such a predefined contract should result in a larger haircut as the expectation of receiving the collateral quickly after counterparty default would be impaired.

Proposition 4.1 (**Legal risk and haircut size**). *Legal risk arising from non-standard lending contracts that might be incomplete and difficult to enforce should c. p. increase the haircut size.*

This legal risk may be accompanied by *operational risk*, which could arise from vague and complex processes both prior to and after counterparty default. Prior to default, a lack of margin regulation would lead to valuation risk (for initial and variation margins, see above). Even if margining is effective, there is a delay between the margin call and the actual adjustment. This operational risk should be reflected in the size of the haircut as it is conditional upon the volatility of the collateral value. The detection and formal declaration of counterparty default and legal processes after default may lead to further delays and potential complications, meaning that it should also be reflected in the haircut to the extent that they are collateral-specific.

Proposition 4.2 (**Operational risk and haircut size**). *Operational risk arising from inefficient margining should c. p. augment the haircut size.*

Once the counterparty has defaulted and the collateral is with the lender, it has to be liquidated to redeem outstanding claims. The outcome of this liquidation is affected by *collateral quality*, which is related to the creditworthiness of its issuer, i.e. the credit risk, as well as its liquidity. Hence, the more likely a default of the collateral issuer, the larger the haircut should be. Likewise, lower liquidity of collateral should imply a larger haircut.

Proposition 4.3 (**Collateral quality and haircut size**). *Collateral quality is determined by collateral credit and liquidity risk.*

i) Higher credit risk as reflected by lower credit ratings should c. p. increase the haircut size.
ii) Higher liquidity risk should c. p. result in a higher haircut size.

The liquidity of marketable assets is particularly determined by risk inherent in the market on which they are traded. This *market risk* manifests in adverse movements of the market value of

[141] See e.g. European Repo Council 2012 and ECB 2015c for overviews of risk types.

collateral between collateral valuation and liquidation. In the event of a crisis and a shock to market confidence, liquidity deteriorates and sudden adverse price movements are likely. This downside volatility implies a greater risk that the lender is unable to settle its outstanding claims.[142] Market risk is lower for official and active markets than for non-regulated markets since the liquidation of collateral is easy and price movements are more transparent and predictable. Nonetheless, the more complex and scarce an asset, the less it will be traded and the more difficult liquidation is, as well as the predictability of price movements. Furthermore, there might be endogenous price movements depending on the quantity of collateral to be liquidated. Moreover, the valuation of marketable assets traded in less liquid markets as well as the theoretical valuation of non-marketable assets gives rise to *valuation risk* as theoretical valuation is prone to errors.[143]

Proposition 4.4 (**Market/valuation risk and haircut size**). *Market risk manifests in the likelihood of adverse movements of the market value between collateral valuation and liquidation. Depending on the market on which assets are traded, valuation methodologies may vary and give rise to valuation risk.*

i) Higher market risk should c. p. increase the haircut size.
ii) Valuation risk should c. p. result in a larger haircut size.

Furthermore, collateral assets typically carry interest in terms of a coupon payment, which affects market valuation and implies *interest-rate risk*, such that it should therefore be reflected in the haircut. Coupons can be variable or fixed-rate and are usually paid once or twice a year.[144] Consequently, market valuation increases between two coupon payments and drops on the day of coupon payment, because sellers in the market seek compensation for accrued interest between two coupon payments. The market price is called the "dirty price" and it only equals the "clean price" on days of coupon payments but is otherwise higher. Variation margins account for this erratic valuation as the collateral value is based on the dirty price. By contrast, zero-coupon bonds are traded at a discount as the interest payment is implied in the difference between the market price and nominal value. Therefore, the market price deviates from the nominal value for zero-coupon bonds because duration in the Macaulay 1938 sense is equal to residual maturity. Residual maturity is another characteristic of collateral that drives up the duration and hence the interest-rate risk of the collateral. A longer residual maturity implies a higher degree of uncertainty about the development of the asset price. Hence, a longer residual maturity should result in larger haircuts. Moreover, zero-coupon bonds with a maturity exceeding one year bear more interest-rate risk and should receive a larger haircut.

Proposition 4.5 (**Interest-rate risk and haircut size**).

i) Interest-rate risk implied in zero-coupon assets (maturity > one year) should c. p. increase the haircut size.

[142] Some of the volatility is absorbed by variation margins. However, at least the difference between the market value at time of counterparty default and the realized liquidation value has to be taken care of by the haircut as no margin calls can be made.
[143] Additionally, margining cannot mitigate risk when assets lack a market value.
[144] However, the variability of the coupon rate is irrelevant for the haircut as they continue to be paid to the borrower.

ii) Interest-rate risk owing to longer residual maturity should c. p. increase the haircut size.

Assets that are pledged as collateral may be issued by an entity with close links to the borrower (see Section 3.1.4.1). In case of close links between the borrower and the collateral issuer, counterparty risk and collateral risk are correlated. Such a correlation implies *wrong-way risk* and it is the highest for own-use collateral as collateral also defaults in case of counterparty default. The effectiveness of pledged assets in collateralized lending transaction is diminished with close links and should be deducted by a larger haircut.

Proposition 4.6 (**Wrong-way risk and haircut size**). *Wrong-way risk arising from close links between the borrower and the collateral issuer should c. p. augment the haircut size.*

Finally, potential exchange-rate risk has to be taken into account if the lender deems eligible collateral in foreign currency. Exchange rates can move between the dates of collateral valuation and collateral liquidation such that haircuts should be larger the higher the *exchange-rate risk*.

Proposition 4.7 (**Exchange-rate risk and haircut size**). *Exchange-rate risk arising from the pledge of assets denominated in foreign currency should c. p. increase the haircut size.*

4.2.2 Development of Applied Haircuts

This section compiles a narrative database on haircuts applied by the Eurosystem in determining the collateral value of assets. General principles of Eurosystem's haircut specification are carved out and a descriptive analysis of the development of haircuts is provided.

4.2.2.1 General Principles of Applied Haircuts

The Eurosystem lays down the haircuts that it applies to eligible assets within its collateral framework. Table 4.2 provides an overview of the dimensions according to which haircuts were differentiated at the end of 2014. Check marks indicate that haircuts were differentiated along that dimension while loops illustrate the opposite. Moreover, check marks in brackets indicate that differentiation was partial, i.e. it did not apply to all assets of the respective liquidity category (LC). Haircuts applied to marketable assets of LCs 1 to 4 were differentiated according to *(i)* CQS, *(ii)* residual maturity and *(iii)* coupon.[145] The haircut applied to LC 5 (which comprised ABSs only) was uniform across residual maturities and irrespective of coupon. Haircuts applied to credit claims were differentiated according to CQS as well as residual maturity in addition to the valuation method (theoretical or outstanding amount). By contrast, haircuts applied to RMBDs were uniform across residual maturities within CQS 1/2 and irrespective of the valuation method and coupon.[146]

In addition to valuation haircuts, the Eurosystem applies supplementary haircuts. These can be applied in the form of *(i)* add-on haircuts, which are simply added to the valuation haircut,

[145] The classification of assets into LCs is based on the issuer and asset type and hence derives liquidity from both the asset type itself as well as the issuer. In October 2013, liquidity categories were renamed in "haircut categories" as their purpose is the assignment of haircuts. The initial name is used for comparability.

[146] Only RMBDs within CQS 1/2 were deemed eligible at the end of 2014 (cf. Section 3.1).

as well as *(ii)* valuation markdowns, which are directly applied at the level of valuation.[147] Whenever the two risk control measures are jointly applied, nominal haircuts (i.e. those that can be directly observed in the tables published by the Eurosystem) and effective haircuts (i.e. those that take into account add-on haircuts and valuation markdowns) differ. The effective haircut h_e is given by

$$h_e \equiv h_n + h_a + v - \underbrace{(h_n + h_a) \cdot v}_{\text{interaction term}}, \tag{4.8}$$

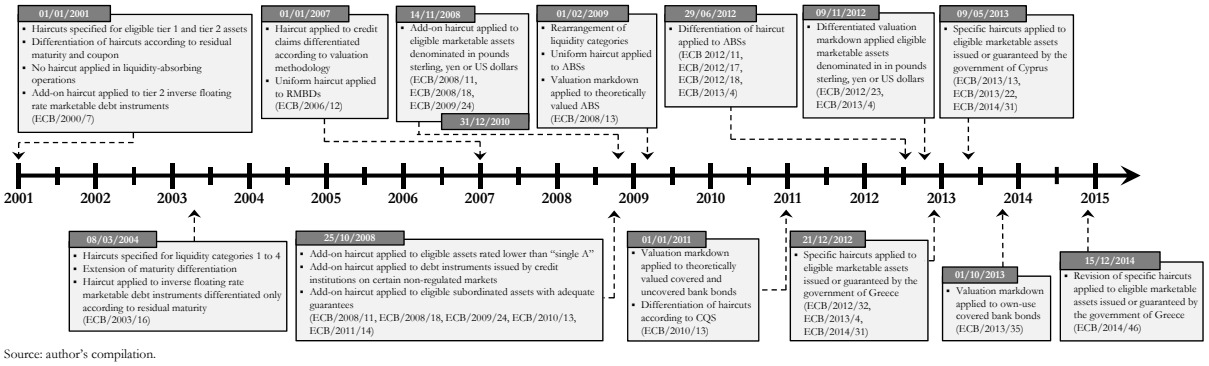
with h_n being the nominal haircut, h_a the add-on haircut and v the valuation markdown. The effective haircut h_e comprises four components, i.e. *(i)* the (nominal) valuation haircut, *(ii)* the add-on haircut, *(iii)* the valuation markdown, and *(iv)* an interaction term between the three. This interaction term is further addressed in Section 4.3.

4.2.2.2 Development of Haircut Specification

The development of Eurosystem haircuts is illustrated in Figure 4.1 and explained hereafter (see also ECB 2015c). Haircuts were already an important part of the initial collateral framework in January 2001 when they were specified for tier 1 and tier 2 assets. Haircuts for tier 1 assets were differentiated according to the type of coupon (fixed-rate, floating-rate, inverse floating-rate) and residual maturity (four cluster: 0 to 1 year, 1 to 3 years, 3 to 7 years, and more than 7 years). The same clustering of residual maturity was applied to assets eligible in tier 2 and haircuts were specified for assets with limited liquidity and special features, as well as non-marketable assets.

Figure 4.1: Changes to Eurosystem haircuts

The figure illustrates the development of Eurosystem haircuts from 2001 to 2014. While haircuts became more differentiated prior to the financial crisis, they were only partly adapted to collateral pool as well as market developments during the financial and sovereign debt crisis. Moreover, the Eurosystem introduced supplementary haircuts to specifically mitigate risk from the extended eligibility of assets.



Source: author's compilation.

This basic framework was first modified in March 2004, the features of which still prevailed at the end of 2014. Tier 1 assets were allocated into LCs according to the issuer and asset type. Two allocations were made irrespective of the issuer, namely ABSs were included in the lowest LC and

[147] Add-on haircuts were e.g. applied to eligible marketable assets denominated in pounds sterling, yen or US dollars from October 2008 to December 2010. When collateral denominated in these currencies was deemed eligible again in November 2012, the add-on haircut was replaced by a valuation markdown.

jumbo Pfandbrief-style debt instruments (later: jumbo covered bank bonds) were summarized in the second LC. Haircuts were differentiated more precisely according to residual maturity as the number of cluster increased from four to six (0 to 1 year, 1 to 3 years, 3 to 5 years, 5 to 7 years, 7 to 10 years, and more than 10 years). Moreover, haircuts were differentiated according to whether the coupon was fixed or zero. For assets with identical properties in terms of residual maturity and coupon, haircuts were decreasing in liquidity, i.e. haircuts increased from LC 1 to 4. Haircuts applied to tier 1 inverse floating-rate instruments were uniform over LCs, depending only on residual maturity. The haircut applied to debt instruments with variable-rate coupons was that applied to a debt instrument with 0 to 1 year residual maturity and fixed-rate coupon within the relevant LC. Haircuts applied to tier 2 assets were elaborated accordingly by including more cluster of residual maturity as well as differentiating between zero and fixed-rate coupon.

The two-tier system was phased out in May 2007 with the introduction of the Single List (cf. Section 3.1.2), which has drawn a distinction between marketable and non-marketable assets. Marketable assets comprised former tier 1 assets and the respective haircuts were applied. Haircuts imposed to credit claims with fixed-rate coupon were differentiated according to the residual maturity and valuation method, while haircuts applied to those with variable-rate coupon were irrespective of the valuation method.[148] A uniform haircut was imposed to RMBDs.

Amendments to haircuts in response to the financial crisis in October 2008 and November 2008 took the form of supplementary haircuts (cf. Section 3.2). First, a uniform add-on haircut was introduced to all eligible assets rated lower than "single A" as the minimum credit rating threshold was lowered from "single A" to "triple B". Second, a uniform add-on haircut was imposed to newly eligible bank bonds traded on accepted non-regulated markets. Third, a uniform add-on haircut was applied to subordinated assets that were deemed eligible with adequate guarantees. Fourth, a valuation markdown was implemented for theoretically valued subordinated assets. Fifth, the Eurosystem charged a uniform add-on haircut to assets denominated in pounds sterling, yen or US dollars that were deemed eligible for the first time from November 2008 to December 2010. Eligibility was reintroduced in November 2012 and the former uniform add-on haircut was replaced by a valuation markdown, which was larger for yen than for pounds sterling or US dollars.

In February 2009, LCs were rearranged with uncovered bank bonds allocated to the fourth and ABSs to the fifth LC (cf. Section 3.2.5). Haircuts on ABSs were harmonized, i.e. they were no longer differentiated with respect to residual maturity, while a uniform valuation markdown was introduced to theoretically valued ABSs. This valuation markdown was extended to theoretically valued covered and uncovered bank bonds in January 2011. At the same time, the Eurosystem lowered the minimum credit rating threshold to "triple B" in the General Framework and replaced the add-on haircut on such assets by more graduated haircuts. More specifically, credit quality was introduced as a fourth dimension of haircut differentiation (besides liquidity, residual maturity and coupon). However, differentiation according to credit quality was limited as only two cluster of credit quality were taken into account with CQSs 1/2 and 3. The limited differentiation of haircuts with respect to credit quality was also implemented for inverse

[148] This held for credit claims with interest payments with a resetting period shorter than one year. Otherwise, credit claims were considered to have a fixed-rate coupon and the respective haircut was applied.

Table 4.2: Differentiation of Eurosystem haircuts at the end of 2014

The table provides an overview of the dimensions according to which the Eurosystem differentiated haircuts at the end of 2014. Check marks indicate that haircuts were differentiated along the specific dimension, while loops illustrate the opposite. Moreover, check marks in brackets indicate that differentiation was partial, i.e. it did not apply to all assets of the respective LC.

	LC	CQS		Residual Maturity						Coupon[a]		Valuation		Close Links[c]	Denomination[d]
		1/2	3	0–1	1–3	3–5	5–7	7–10	>10	zero	fixed	theoretical[b]	outstanding amount		
Marketable Assets	1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	O	O	O	✓
	2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	(✓)	O	(✓)	✓
	3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	(✓)	O	(✓)	✓
	4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	(✓)	O	O	✓
	5	✓	✓	O	O	O	O	O	O	O	O	(✓)	O	O	✓
Non-Marketable Assets	Credit Claims	✓	✓	✓	✓	✓	✓	✓	✓	O	O	✓	✓	O	O
	RMBDs	✓	O	O	O	O	O	O	O	O	O	O	O	O	O

[a] Debt instruments with variable-rate coupons were treated as debt instruments with a fixed-rate coupon and 0-1 year residual maturity in the relevant LC. Specific haircuts are applied to inverse floating-rate debt instruments.
[b] A supplementary haircut in terms of a valuation markdown was applied to theoretically valued covered and uncovered bank bonds as well as ABSs.
[c] A supplementary haircut in terms of a valuation markdown was applied to own-use covered bank bonds, which differed across CQSs.
[d] As of November 2012, a supplementary haircut in terms of a valuation markdown was applied to all marketable debt instruments denominated in foreign currency. It differed between yen and other foreign currencies, i.e. pounds sterling and US dollars.
Source: author's compilation.

floating-rate debt instruments and credit claims with fixed interest payments. The lowering of the credit rating requirement for homogenous ABSs in June 2012 was accompanied with the introduction of larger haircuts for these newly eligible ABSs within CQS 3, which were differentiated with respect to underlying assets.[149] Furthermore, a valuation markdown was imposed to own-use covered bank bonds in October 2013, which was differentiated according to credit quality.

Section 3.2.2 revealed that the collateral criteria of bonds issued or guaranteed by governments were subject to substantial amendments and that country-specific criteria were introduced in May 2010 when the minimum credit rating was suspended for bonds issued or guaranteed by the government of Greece. This step was repeated for Ireland (April 2011), Portugal (July 2011) and Cyprus (May 2013). Specific and considerably larger haircuts were adopted for government bonds and government-guaranteed bank bonds as well as non-financial corporate bonds issued in Greece and Cyprus, but not for Ireland and Portugal. The specific haircuts were revised and lowered throughout 2014.

4.2.3 Descriptive Analysis of Applied Haircuts

Having carved out general principles and compiled a narrative database of the development of haircuts applied by the Eurosystem, this section elaborates on the quantitative development of haircuts. It aims to draw a comprehensive picture of the quantitative development of haircuts and takes into account the different components of effective haircuts of the Eurosystem: *(i)* the (nominal) valuation haircut h_n, and *(ii)* supplementary haircuts, i.e. add-on haircuts h_a and valuation markdowns v.

4.2.3.1 (Nominal) Valuation Haircuts

The following analysis of nominal haircuts suggests four broad phases of haircut development:

- pre-crisis phase: April 2004 to September 2008;
- financial crisis phase: October 2008 to December 2010;
- sovereign debt crisis phase: January 2011 to September 2013;
- remittent sovereign debt crisis phase: October 2013 to December 2014.

The timing of the phases suggests that the Eurosystem responded to the onsets of the financial and the sovereign debt crisis with delays, whereby the response was faster for the former rather than the latter. Despite being the major risk mitigation tool, adjustments to haircuts were scarce and infrequent, as well as not always being specifically related to events during the phases (see also Nyborg 2015). For instance, haircut adjustments during the sovereign debt crisis phase were only secondarily addressed to government-related assets.

Figure 4.2 provides a comprehensive picture of the quantitative development of nominal haircuts applied by the Eurosystem from March 2004 to December 2014 to assets in LCs 1 to 5,

[149] For ABSs that did not have two ratings of at least "single A", the haircut was differentiated with respect to underlying assets, whereby those ABSs backed by commercial mortgages were subject to a larger valuation haircut than other eligible ABSs. The haircuts were lowered in October 2013.

inverse floating-rate debt instruments, credit claims as well as RMBDs, arranged by CQSs.[150] Based on the information illustrated in Figure 4.2, haircuts applied during the four phases are characterized according to the following two properties:[151] first, the average haircut seizes on the level of haircuts; and second, the haircut range illustrates the spread of haircuts between the smallest and largest haircut. The range is defined as the difference between the haircut applied to assets with the shortest (0 to 1 year) and the longest (more than 10 years) residual maturity.

Pre-Crisis Phase The Eurosystem did not change haircuts within this first phase. Only assets of good quality, i.e. rated within CQS 1/2, were eligible and Table 4.3 indicates that initial average haircuts as well as haircut ranges were moderate and increased with diminishing liquidity of assets. Haircuts applied to ABSs were still differentiated according to residual maturity, while a uniform haircut of 20% was applied to all eligible RMBDs.

Table 4.3: Nominal valuation haircuts during the pre-crisis phase

The table characterizes haircuts applied prior to the financial crisis, indicating that initial average haircuts as well as haircut ranges were moderate and increased with decreasing liquidity.

	Average Haircut (in percentage points)	Haircut Range (in percentage points)
LC 1	2.83	5
LC 2	4.08	6.5
LC 3	5	7.5
LC 5[a]	6.25	10
Inverse Floater	12.17	23
Credit Claims	11.5	10
RMBDs	20	0

[a] ABSs made up for LC 4 at that time are indicated as LC 5 into which they were classified in February 2009.
Source: author's calculation.

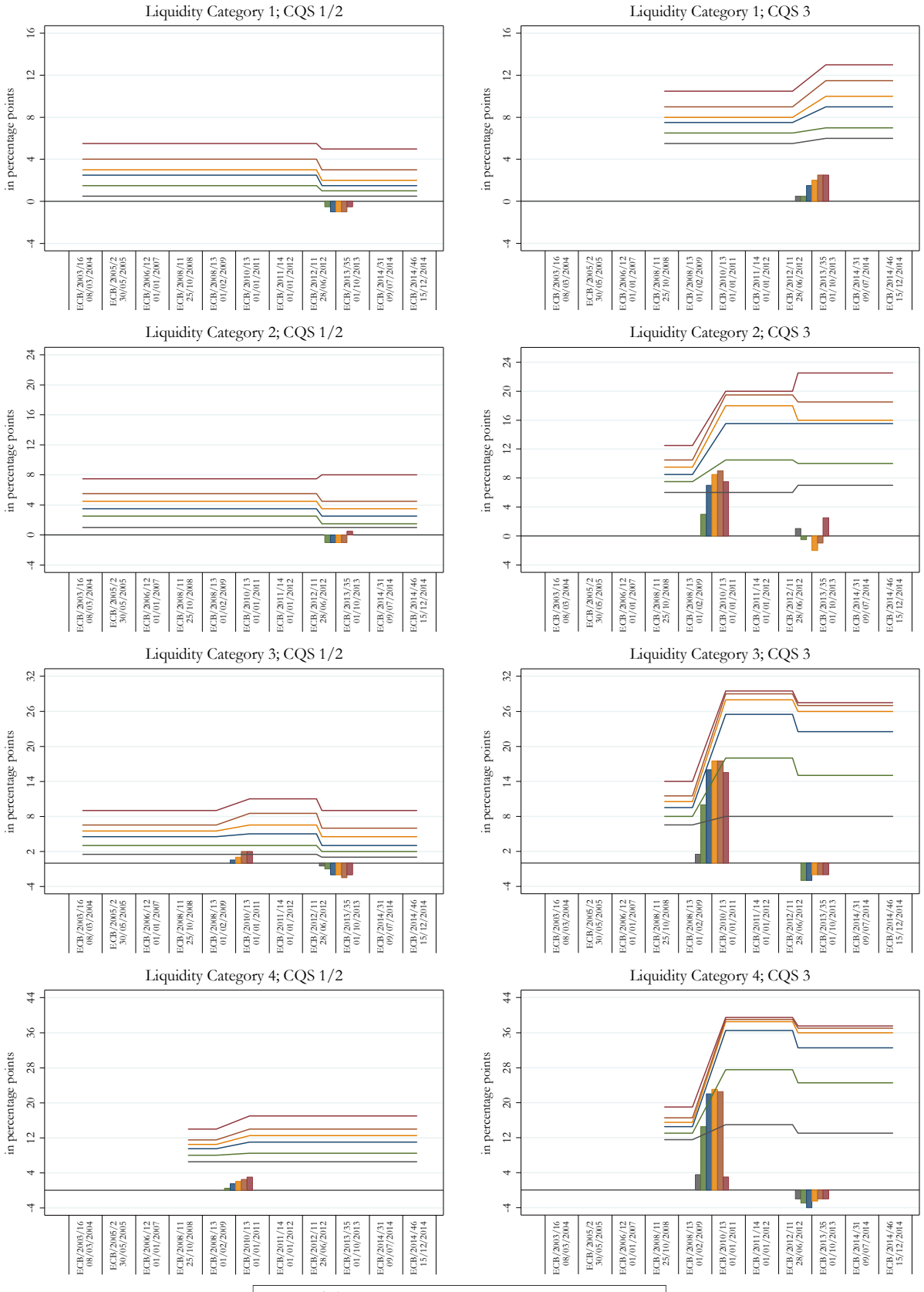
Financial Crisis Phase Turmoil in financial markets predominantly impaired the quality of bank bonds, which were comprised in LCs 2 (Jumbo covered bonds) and 3 (traditional covered bonds and uncovered bonds) at the time. Moreover, the market for ABSs almost completely dried up. Higher credit risk as well as lower liquidity owing to the distressed market environment should—according to Proposition 4.3—have called for larger haircuts on bank bonds and ABSs.

While the Eurosystem promptly reacted to the turmoil by adapting its collateral framework in October 2008 and the subsequent months, amendments to haircuts were initially small. The lowering of the minimum credit rating threshold was accompanied by applying an add-on haircut of 5% to the newly eligible assets of lower quality within LCs 1 to 3. However, initial haircuts

[150] The figures illustrate the quantitative development of nominal valuation haircuts imposed on collateral with fixed-coupon payments. For credit claims, the average of the haircut applied to theoretically valued credit claims and those valued according to the outstanding amount is shown. The add-on haircut applied to eligible collateral in CQS 3 from October 2008 to December 2010 is treated as a nominal valuation haircut for the sake of comparability. All other supplementary haircuts are neglected.

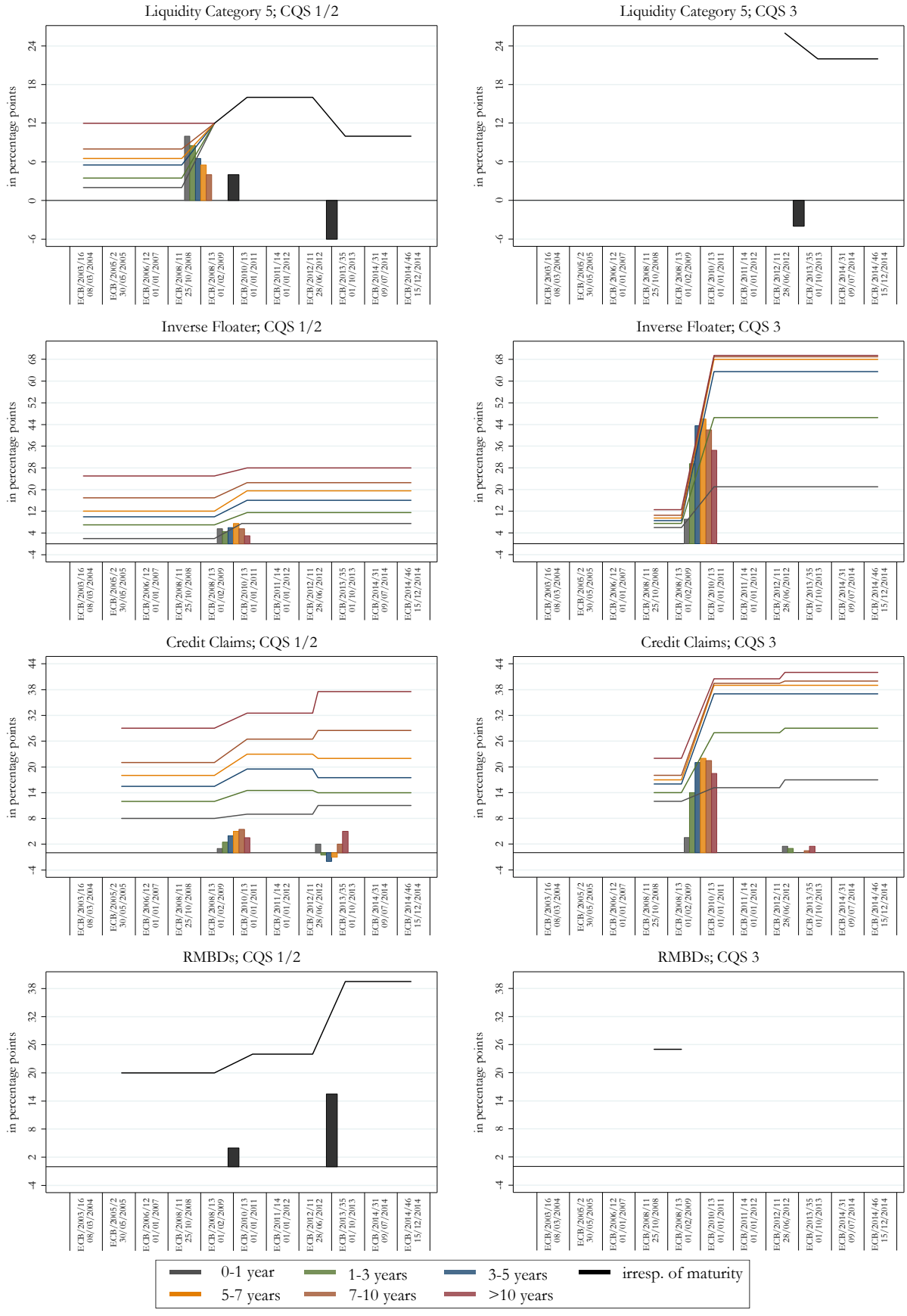
[151] Haircut properties are given for collateral with fixed-rate coupon and theoretical valuation in case of credit claims.

Figure 4.2: Quantitative development of nominal valuation haircuts



Source: author's compilation; European Central Bank.

Figure 4.2: Quantitative development of nominal valuation haircuts (cont.)



Source: author's compilation; European Central Bank.

were not adjusted until February 2009 when the Eurosystem reacted to the changing market environment by reclassifying uncovered bank bonds in LC 4 and ABSs in LC 5. The average haircut applied to uncovered bank bonds was raised from 5% to 10%, while the range remained at 7.5%, i.e. uncovered bank bonds were effectively deducted by another add-on haircut of 5% irrespective of residual maturity as of February 2009. Haircuts applied to ABSs (LC 5), which were hitherto differentiated according to residual maturity, were harmonized to the haircut formerly applied to ABSs with the longest residual maturity (more than ten years). Therefore, the haircut increase was greater the shorter the residual maturity of ABSs, while the average haircut increased from 6.25% to 12%.

Sovereign Debt Crisis Phase While the European sovereign debt crisis intensified in the course of 2010, the Eurosystem did not amend haircuts until January 2011. The debt crisis mainly affected government bonds that were eligible as collateral within LC 1 as well as government-guaranteed assets and bank bonds eligible in LCs 2 to 4. Larger haircuts should have been imposed on these assets according to Proposition 4.3 as credit quality and liquidity deteriorated. However, changes were not specifically directed at government-related assets but predominantly owed to the revision of the uniform add-on haircut of 5% applied to eligible assets of lower credit quality (CQS 3) in LCs 1 to 4. The uniform add-on haircut was replaced by more graduated haircuts, which were differentiated according to residual maturity and coupon (see Section 4.2.2.2). Table 4.4 provides an overview of the modifications that can be tracked in Figure 4.2. The comparison of Tables 4.3 and 4.4 indicates that haircuts applied to government bonds (incorporated in LC 1) were not subject to change. By contrast, modifications implied substantial increases in haircuts applied to assets within LCs 2 to 4 in CQS 3, which were larger in absolute terms for higher LCs (i.e. less liquid assets). Residual maturities within LCs were treated differently, as indicated by the pattern of change in Table 4.4 and tracked in Figure 4.2. The general impression is that absolute increases in haircuts mainly reflected an inverse u-shaped pattern, implying that increases were large for assets of medium (3-5 and 5-7 years) but small or zero for those with short (0-1 and 1-3 years) and long (7-10 and larger than 10 years) residual maturity. Average haircuts increased for all assets aside from those in LC 1 and high-quality assets (i.e. CQS 1/2) in LC 2. The credit quality and liquidity of bonds issued or guaranteed by several countries further impaired throughout 2011 with the aggravation of the sovereign debt crisis. The Eurosystem thus suspended (or extended the suspension) of the minimum credit rating for bonds issued or guaranteed by Greece, Ireland, Portugal and Cyprus. Declining credit quality and liquidity of government-related collateral in those countries was accompanied by specific modifications to haircuts applied to government-related assets from Greece and Cyprus. For Greece, the average haircut increased from 9.4% to 43.3% (government bonds) and from 22% to 53.3% (government-guaranteed bonds). For Cyprus, the average haircut increased from 9.4% to 37.5% (government bonds) and from 22% to 47.5% (government-guaranteed bonds).

Remittent Sovereign Debt Crisis Phase The Eurosystem reacted cautiously to the calming of financial markets, which suggested the remittance of the sovereign debt crisis as it did not modify haircuts until the end of 2014. The improved market environment in terms of improved

Table 4.4: Changes to nominal valuation haircuts during the debt crisis phase

The table provides an overview of the changes to nominal haircuts during the sovereign debt crisis phase, which can be tracked in Figure 4.2. Changes implied substantial increases in haircuts applied to assets within LCs 2 to 4 in CQS 3. Increases were larger in absolute terms for higher LCs, i.e. less liquid assets. Residual maturities within LCs were treated differently, as indicated by the pattern of change.

	Haircuts in CQS 1/2			Haircuts in CQS 3		
	Ø[a]	Range[a]	Pattern	Ø[a]	Range[a]	Pattern
LC 1	2.8	5	no change	7.8	5	no change
LC 2	4.1	6.5	no change	14.9	14	inverse u-shaped increase[b]
LC 3	5.9	9.5	increase	23	21.5	inverse u–shaped increase
LC 4	11.6	10.5	strict increase	32.7	24.5	inverse u–shaped increase
LC 5	16	0	increase[c]	n/a	n/a	n/a
Inverse Floater	17.5	20.5	inverse u–shaped increase[d]	56.3	48.5	uniform increase
Credit Claims	15.1	12.5	inverse u–shaped increase	33.3	25	inverse u–shaped increase
RMBDs	24	0	increase[c]	n/a	n/a	n/a

[a] In percentage points.
[b] The inverse u-shaped pattern implies that the change is large for assets with medium (3-5, 5-7) but small or zero for assets with short (0-1, 1-3) and long (7-10, >10) residual maturity.
[c] Irrespective of residual maturity.
[d] Except for inverse floaters with residual maturity between 0 to 1 year.
Source: author's compilation.

credit quality and liquidity of government-related assets should have resulted in a reduction of haircuts (Proposition 4.3). In fact, haircuts were modified for all LCs as well as credit claims and RMBDs in October 2013. However, modifications were small in magnitude relative to increases in haircuts performed during the previous (debt crisis) phase. Unlike previously, modifications were also directed at government bonds (or LC 1, respectively) such that haircuts were lowered for government bonds of high credit quality (CQS 1/2) but strictly increased for lower-quality assets (CQS 3). Exceptions were ABSs (LC 5) for which the uniform haircut was lowered by more than it was increased in the previous phase, as well as RMBDs, for which the haircut was further increased. The overall pattern of modifications was more divergent than previously, as Figure 4.2 indicates and Table 4.5 summarizes. Haircuts were predominately modified in a u-shaped pattern, i.e. changes were mainly directed to assets of shorter and longer residual maturity. As modifications were small in magnitude, average haircuts and ranges did not vary substantially relative to the previous phase. Moreover, the Eurosystem considerably lowered the specific haircuts applied to bonds issued or guaranteed by the government of Greece. The average haircut on Greek government bonds decreased to 21.8% (from 43.4%) and the haircut applied to bonds guaranteed by the Greek government fell to 30.3% (from 53.3%). Special haircuts for collateral related to the Cypriot government were not altered.

Table 4.5: Changes to nominal valuation haircuts during the remittent debt crisis phase

The table provides an overview of the changes to nominal haircuts during the remittent sovereign debt crisis phase, which can be tracked in Figure 4.2. Modifications were small in magnitude relative to haircut increases during the previous phase. Changes were also directed at government bonds (or LC 1, respectively). Inverse floaters are neglected as no changes were made.

	Haircuts in CQS 1/2			Haircuts in CQS 3		
	Ø[a]	Range[a]	Pattern	Ø[a]	Range[a]	Pattern
LC 1	2.2	4.5	u-shaped decrease[b]	9.4	7	increase
LC 2	3.5	7	constant decrease[c]	14.9	15.5	u-shaped modification[d]
LC 3	4.6	9.5	u-shaped decrease	19.5	19.5	decrease
LC 4	11.6	10.5	no change	30.1	24.5	u-shaped decrease
LC 5	10	0	decrease[e]	22	0	decrease[e]
Credit Claims	15.1	12.5	u-shaped modification[f]	33.3	25.5	u-shaped increase
RMBDs	39.5	0	increase[e]	n/a	n/a	n/a

[a] In percentage points.
[b] The u-shaped pattern implies that the change in haircuts is small or zero for assets with medium (3-5, 5-7) but large for assets with short (0-1, 1-3) and long (7-10, >10) residual maturity.
[c] Except for assets with residual maturity of more than 10 years, for which the haircut was increased.
[d] Increase only for assets of the shortest (0-1) and longest (>10) residual maturity.
[e] Irrespective of residual maturity.
[f] Increase only for assets of with residual maturity 0-1, 7-10 and more than 10 years.
Source: author's compilation.

4.2.3.2 Supplementary Haircuts

Section 4.2.2 has revealed that besides nominal haircuts, the Eurosystem also applies supplementary haircuts. Accordingly, this section briefly reviews and summarizes the quantitative development in the application of the two types of supplementary haircuts: *(i)* add-on haircuts, i.e. h_a, and *(ii)* valuation markdowns, i.e. v. Table 4.6 provides an overview of add-on haircuts and valuation markdowns applied by the Eurosystem from 2001 to 2014 together with the affected collateral, haircut size and the period of application. It reveals that the Eurosystem applied add-on haircuts in particular after the onset of the financial crisis and the following quantitative and qualitative broadening of eligible collateral. The Eurosystem later replaced former add-on haircuts and shifted towards the application of valuation markdowns.

4.3 Evaluation and Shortcomings of the Haircut Specification

Building on the previous analysis of haircuts, Eurosystem haircut application is evaluated against the general principles of haircut specification carved out in Section 4.2.1. Based on this evaluation, shortcomings of Eurosystem haircuts are subsequently pointed out.[152]

[152] See also Nyborg 2015 for an assessment of Eurosystem haircuts.

Table 4.6: Overview of supplementary haircuts applied by the Eurosystem

The table provides an overview of supplementary haircuts, i.e. add-on haircuts and valuation markdowns, applied by the Eurosystem from 2001 to 2014. It reveals that the Eurosystem applied add-on haircuts in particular during the financial crisis but later turned to valuation markdowns.

Affected Collateral	Type	Size	Application Period
eligible assets rated lower than "single A"	add-on haircut	5%	25/10/2008–31/12/2010
bank bonds traded on non-regulated markets	add-on haircut	5%	25/10/2008–31/12/2010
foreign currency collateral	add-on haircut	8%	14/11/2008–31/12/2010
subordinated assets	add-on haircut	10%	14/11/2008–31/12/2010
theoretically valued subordinated assets	valuation markdown	5%	14/11/2008–31/12/2010
theoretically valued ABSs	valuation markdown	5%	01/02/2009–today
theoretically valued covered and uncovered bank bonds	valuation markdown	5%	01/01/2011–today
foreign currency collateral	valuation markdown	16%/26%[a]	09/11/2012–today
own-use covered bank bonds	valuation markdown	8%/12%[b]	01/11/2013–today

[a] 16% for GBP and USD; 26% for JPY.
[b] 8% for bank bonds in CQS 1/2 and 26% for those in CQS 3.
Source: author's compilation.

4.3.1 Evaluation of the Haircut Specification

Proposition 4.1 explored the effect of legal risk on haircut size and postulated that legal risk arising from non-standard lending contracts calls for larger haircuts as these contracts might be incomplete or difficult to enforce. The Eurosystem uses the European Master Agreement for its relevant transactions (ECB 2006b) and ensures that no legal risk arises from the contractual framework of a transaction. Hence, there is no necessity for larger haircuts owing to legal risk.

Proposition 4.2 addressed the link between operational risk and haircuts and claimed that operational risk from e.g. inefficient margining should imply larger haircuts. The Eurosystem applies variation margins according to which counterparties have to maintain the collateralization of principal over time (see Section 4.1). Recalculation is performed daily and includes accrued interest. Usually, a variation margin of 0.5% of principal is used as a trigger point for a margin call.

Proposition 4.3 elaborated on the bearing of collateral quality on haircut size and claimed that the collateral of lower credit quality and liquidity should have larger haircuts. The Eurosystem effectively distinguishes three CQSs in its collateral framework. Haircuts do not continuously increase with diminishing credit quality; instead, they jump when an eligible asset moves from CQS 1/2 to CQS 3, and drop vice versa. Hence, the haircut application of the Eurosystem only partially meets Proposition 4.3 with respect to the effect of credit quality on haircut size. Moreover, the Eurosystem takes collateral liquidity into account. Haircuts are differentiated

according to five LCs and different haircuts are applied to eligible non-marketable assets. Assets are assigned to LCs depending on their type and issuer. Hence, the development of haircuts applied to marketable assets is only partially differentiated according to liquidity.

Proposition 4.4 considered the effect of market risk on haircut size and inter alia claimed that assets subject to valuation risk should bear larger haircuts. The Eurosystem applies a valuation markdown of 5% to theoretically valued covered and uncovered bank bonds as well as ABSs to address valuation risk. In addition, different haircuts are applied to credit claims depending on the valuation method. The Eurosystem recognized that bank bonds traded on non-regulated markets would bear higher market risk and thus it applied an add-on haircut to these assets from October 2008 to December 2010. However, the Eurosystem refrained from applying a supplementary haircut when bank bonds traded on non-regulated markets were again deemed eligible as of January 2012.

Proposition 4.5 asked for larger haircuts in case of higher interest-rate risk owing to e.g. the longer residual maturity of collateral. Eurosystem haircuts are differentiated with respect to six cluster of residual maturity. Generally, haircuts increase in residual maturity to recognize the higher interest-rate risk associated with longer duration. Analogous to haircut differentiation according to credit quality and liquidity, residual maturity does not imply a continuous effect on haircut size as haircuts only change when residual maturity moves from one cluster to the other. Hence, Proposition 4.5 is met with restrictions. The Eurosystem applies haircuts to zero-coupon assets that are the same or larger than to fixed-coupon assets. No difference is made in case of collateral maturing within one year as the duration does not significantly differ for these assets. Variable-rate coupons are treated like fixed-rate coupons and haircuts are applied according to residual maturity, which corresponds to the resetting period of the variable-rate coupon.

Proposition 4.6 dealt with the effect of wrong-way risk on haircut size. It called for larger haircuts the closer the connection between the counterparty and collateral issuer. In fact, the Eurosystem applies a supplementary haircut in terms of a valuation markdown of 8% to own-use covered bank bonds rated in CQS 1/2 and 12% in CQS 3. However, other assets eligible with close links (especially own-use government-guaranteed uncovered bank bonds) are not subject to a supplementary haircut.

Finally, Proposition 4.7 addressed exchange-rate risk and claimed larger haircuts when collateral is denominated in foreign currency. The Eurosystem deemed eligible collateral denominated in pounds sterling, yen or US dollar from November 2008 to December 2010 and again as of November 2012. It applied a uniform add-on haircut during the first period, which was replaced by a differentiated valuation markdown in November 2012.

4.3.2 Shortcomings of the Haircut Specification

The previous section revealed that the Eurosystem oversimplifies haircut specification as in particular Propositions 4.3 and 4.5 are only met to a limited extent. This section argues that the application of Eurosystem haircuts is associated with the following four flaws: *(i)* the application of the first-best rule; *(ii)* the remoteness from market conditions and infrequent revision; *(iii)*

the sequential application of valuation markdowns and haircuts; and *(iv)* the clustering of assets properties.

4.3.2.1 Application of First-Best Rule for Credit Assessment

Credit assessment is crucial for risk control as haircuts are applied based on the assessed credit quality. Section 3.1.4.3 showed that the Eurosystem assesses credit quality of eligible marketable assets (except for ABSs) based on a first-best rule. Accordingly, the Eurosystem only takes into account the best rating when credit ratings of rating agencies differ. Owing to the application of the first-best rule, the Eurosystem ignores available information on credit quality, which should be taken into account for risk control. Moreover, it incentivizes rating agencies to be pivotal, i.e. to exert influence on whether assets are eligible and/or on the applied haircut. This can give rise to an artificial "race to the top" of ratings irrespective of the actual credit quality and facilitate "ratings shopping" by counterparties as it was generally observed in the preface of the financial crisis (e.g. Skreta and Veldkamp 2009, Becker and Milbourn 2011, Bolton et al. 2012). One facile way to alleviate this problem would be to apply a second-best or even last-best rule in case of differing rating assessments, which would imply a requirement for a certain minimum number of assessments. The second-best rule together with the requirement of at least two credit ratings was already applied to ABSs as of October 2010.

4.3.2.2 Remoteness from Market Conditions and Infrequent Revision

The Eurosystem differentiates haircuts along various dimensions such that they reflect asset-specific properties such as credit quality and liquidity (albeit to a limited extent). However, haircuts fail to reflect the latest developments in market conditions owing to their low level of market input and infrequent revision. Section 4.2.3 revealed that haircuts were revised infrequently and often lagged in response to developments in financial markets and amendments to collateral criteria. Nyborg 2015 documents an average time between broad haircut revision of more than three years. Indeed, this impression is confirmed by Figure 4.2.

4.3.2.3 Sequential Application of Valuation Markdowns and Haircuts

Another shortcoming is the sequential application of risk control measures. Nominal and add-on haircuts are applied after valuation markdowns are imposed, which are applied directly when collateral valuation takes place as they aim to alleviate uncertainty from asset valuation. Therefore, it makes sense to apply valuation markdowns as a precautionary means to theoretically valued assets. However, Table 4.6 indicates that valuation markdowns replaced former add-on haircuts and were also applied to foreign currency collateral irrespective of the valuation method. This is precarious as the sequential application gives rise to interaction between the valuation markdown and haircuts (see also Section 4.2.2.1). This interaction term is reflected by

$$\Phi = (1 - h_n - h_a)(1 - v)\Omega = \big(1 - h_n - h_a - v + \underbrace{(h_n + h_a) \cdot v}_{\text{interaction term}}\big)\Omega. \tag{4.9}$$

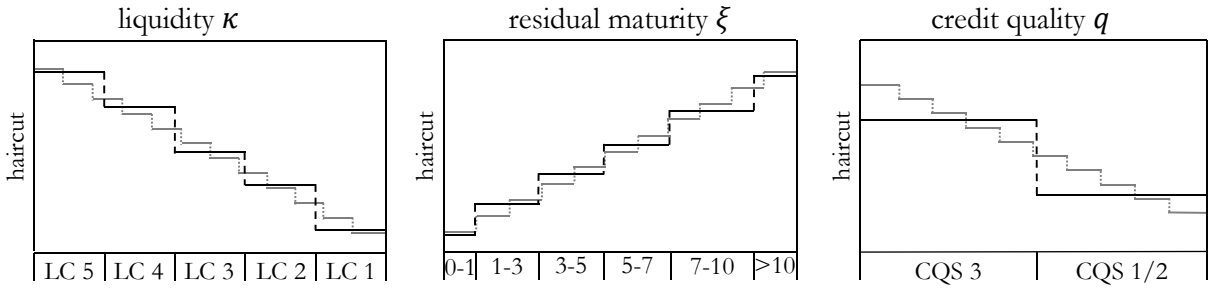
Interaction effectively augments the collateral value of an asset as it alleviates the applied haircut. This alleviating effect is greater the larger the haircut applied to the assets, i.e. the lower the collateral quality. The interaction term would vanish if valuation markdowns and haircuts were applied simultaneously, with larger haircuts resulting accordingly.

4.3.2.4 Clustering of Asset Properties

The Eurosystem recognized four determinants of nominal haircuts applied to eligible marketable assets at the end of 2014: *(i)* coupon, *(ii)* liquidity, *(iii)* credit quality and *(iv)* residual maturity. The haircut is differentiated according to whether the coupon is fixed, zero or variable. Therefore, all potential coupon structures are considered and all available information affects the haircut size. However, this does not hold for the other three determinants, for which information is summarized into five (liquidity), two (credit quality) and six (residual maturity) cluster. This reflects the Eurosystem's endeavor to specify haircuts that take account "of the main [...] risk differences, in as few dimensions as possible" (ECB 2015c, p. 29). Neglecting coupon structure for simplicity, the nominal haircut h_n in Equation (4.8) can be formulated as $h_n(q, \kappa, \xi)$, i.e. it depends on credit quality q, liquidity κ and residual maturity ξ. The effect of q, κ and ξ on h_n as assumed by the Eurosystem in haircut specification is stylized in Figure 4.3. The obvious shortcoming is that q and κ are discrete arguments and although ξ is generally a continuous argument, it has to be discretized to be applicable. Hence, a continuous function $h_n(q, \kappa, \xi)$ can neither be derived nor would it be tractable. However, it is apparent that the Eurosystem clusters asset properties, which implies a concentration and negligence of information. This information would be available to elaborate more graduated haircuts as exemplified in gray, which would imply more accurate differentiation. The problems associated with clustering asset properties like liquidity and credit quality is addressed in the following and emphasized in Buiter and Sibert 2005. The study ascribes low interest spreads on government bonds in the Eurozone prior to the sovereign debt crisis to the application of equal haircuts to government bonds of distinct credit quality.

Figure 4.3: Clustering of asset properties in haircut specification

The figure stylizes the relation between the nominal haircut h_n and asset liquidity κ, asset residual maturity ξ as well as asset credit quality q, as assumed by the Eurosystem in haircut specification. It depicts the broad clustering of asset properties as haircuts are harmonized for e.g. up to seven credit rating notches (S&P scale). Moreover, more graduated haircut specification is indicated in gray.



Source: author's illustration.

Liquidity The Eurosystem clusters different asset types into five liquidity categories (LCs). By the end of 2014, LC 1 comprised two asset types, LC 2 four types, LC 3 three types, LC 4 two types and LC 5 only ABSs. Hence, the Eurosystem harmonized haircuts within LCs for up to four asset types, assuming that the assets would be equally liquid. Taking into account that asset types may differ in liquidity, haircuts may have been too large for some assets and too small for others. Generally, the application of harmonized haircuts to assets of different liquidity meets Proposition 4.3, albeit with restrictions.

Residual Maturity Likewise, the Eurosystem consolidates residual maturity into six clusters with a range of up to four years in each cluster (disregarding the cluster ">10"). Figure 4.4 depicts the development of the distribution of assets within clusters from May 2007 to December 2013 measured by the deviation of the median residual maturity from the cluster mean.[153] The figure indicates that the distribution of assets within clusters was usually right-skewed, i.e. more assets had a residual maturity shorter than the cluster mean. Distribution of assets developed volatile during the crises but returned to be more symmetric again at the end of 2013. The problem arising from the asymmetric distribution of assets originates from the uniform haircut applied within each cluster. If the haircut was specified according to the cluster mean, a right-skewed distribution would imply more assets being deducted by an overly-large haircut. While this would be advantageous from a risk mitigation perspective, it would have adverse effects on collateral availability within the Eurozone. By contrast, the application of a uniform haircut which reflects the cluster mean together with a left-skewed distribution of assets would give rise to insufficient risk control. In general, the application of uniform haircuts to assets of different residual maturity gives rise to haircuts that do not reflect the true collateral risk and thus Proposition 4.5 is only met with restrictions.

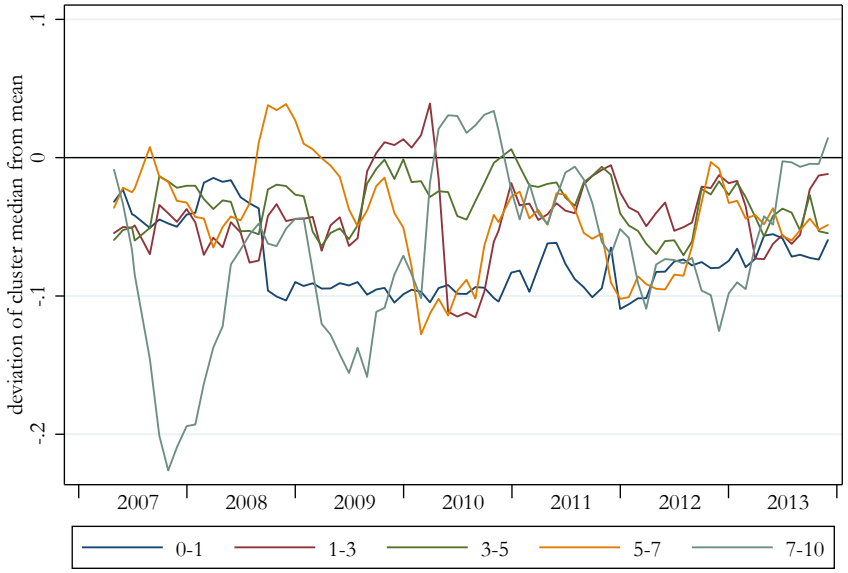
Credit Quality Asset properties are clustered to the largest degree for credit quality. The Eurosystem defines three CQSs that comprise credit ratings from "triple A" to "triple B" (cf. Section 3.1.4.3).[154] Figure 4.5 exemplifies the harmonization of credit ratings for the rating scale of S&P. The four credit rating notches from "AAA" to "AA-" are summarized into CQS 1, the three subsequent notches from "A+" to "A-" are collected in CQS 2 and finally the last three notches above non-investment grade, i.e. "BBB+" to "BBB-", are aggregated into CQS 3. For the purpose of haircut application, the Eurosystem aggregates CQS 1 and 2 into one credit quality cluster and uses CQS 3 as the other cluster. Thus, assets of seven and three credit rating notches are subsumed into two credit quality clusters. For instance, an eligible covered bank bond with a fixed-rate coupon and residual maturity of two years that is rated "AAA" and features (according to S&P) a "capacity to meet [the] financial commitment [which] is extremely strong" (cf. S&P 2012, p. 5) receives the same haircut as a covered bank bond with fixed-rate coupon and residual maturity of two years that exhibits a credit rating of "single A" and is "susceptible to the adverse effects of changes in circumstances and economic conditions" (cf. S&P 2012, p. 5).

[153] Cluster ">10" is neglected as an outlier.

[154] The introduction of the ACCs framework and the suspension of the minimum credit rating implied that the Eurosystem implicitly introduced another CQS, i.e. CQS 4.

Figure 4.4: Distribution of assets within the residual maturity clusters

The figure elaborates on the development of the distribution of eligible marketable assets within the residual maturity clusters from 2007 to 2013. The distribution is important as uniform haircuts are applied within each cluster. It illustrates the deviation of the median residual maturity within each cluster from the cluster mean. It indicates that the distribution within cluster was predominantly right-skewed, i.e. more assets had a residual maturity shorter than the natural cluster mean. Moreover, distributions considerably fluctuated over time.



Source: author's calculation; European Central Bank, *Eligible Assets Database*.

In general, the application of uniform haircuts to assets of different credit quality violates Proposition 4.3, which inter alia calls for higher credit risk to be reflected by larger haircuts. For risk mitigation, a uniform haircut would not be worrisome if it mirrored the risk profile of the lowest-rated asset within each cluster. Nevertheless, haircuts would subsequently be too cautious and would restrict collateral availability.

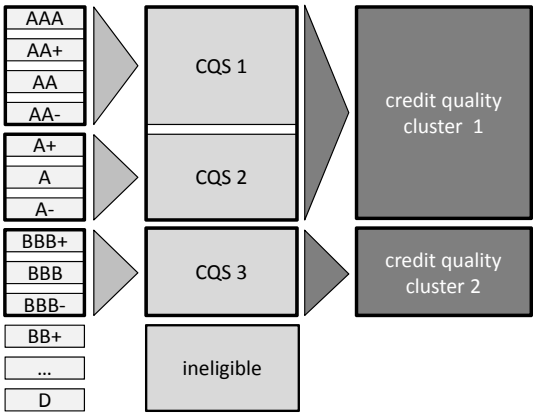
Figure 4.6 reconstructs the distribution of eligible marketable assets across credit rating notches for one day (6 March 2015).[155] Both short- and long-term as well as issue and issuer ratings of eligible marketable assets were collected from Bloomberg and the rules of the Eurosystem for determining the pivotal credit rating were adapted (see Section 3.1.4.3). Accordingly, the first-best rule was applied in case of distinct ratings and issue ratings were preferred over issuer ratings (when both ratings were available).[156] Rating notches are given on the horizontal axis (from low to high) and the vertical axis depicts the frequency of assets for each notch. On 6 March 2015, 76.7% of eligible marketable assets were rated within CQS 1/2 and 15.7% in CQS 3. No issue or issuer rating was available for the residual (7.6%) on the specific day. The figure reveals that the distribution of assets within CQSs considerably varied. Within CQS 3, the frequency of assets increases in credit quality. This pattern is also observable for CQS 1/2, although a large fraction of assets in CQS 1/2 was rated as "A" and only very few assets were rated "AA+" or "AA-". The distribution implies that the application of a uniform haircut to assets in the same CQS leaves a considerable fraction of assets with an overly-small or -large

[155] Data providers like Bloomberg only make available ratings on a daily basis but no historical record is provided. See also Section 3.3.4.

[156] Ratings were translated into the rating scale of S&P for the sake of simplicity.

Figure 4.5: Clustering of asset credit quality (exemplified for the rating scale of S&P)

This figure stylizes the clustering of asset credit quality for the rating scale of S&P. It illustrates how the Eurosystem clusters asset credit quality in two steps: first, rating notches are subsumed into CQSs; and second, CQSs are summarized into credit quality clusters.

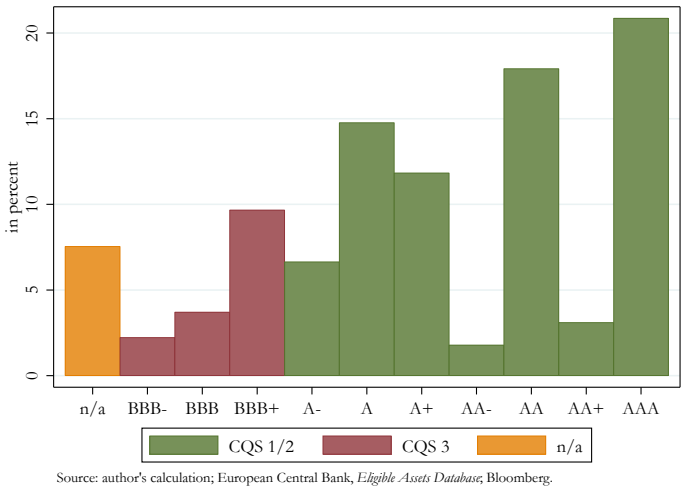


Source: author's illustration.

haircut. If e.g. the uniform haircuts in CQSs 1/2 and 3 were set according to the risk profile of assets rated as "AA" and "BBB", respectively, 33.6% of all assets were deducted by a haircut which would have been too high and 37.2% with an overly-small haircut. The haircut would have hedged collateral default risk correctly for only 21.6% of eligible marketable assets.

Figure 4.6: Distribution of eligible marketable assets within CQSs (on 6 March 2015)

The figure identifies the credit quality of eligible marketable assets in terms of rating notches on 6 March 2015. Accordingly, it reconstructs the distribution of eligible marketable assets across CQSs for one day. Both short- and long-term as well as issue and issuer ratings were collected from Bloomberg and the rules of the Eurosystem for determining the pivotal credit rating were applied. The figure indicates that assets were distributed asymmetrically within CQSs.



Source: author's calculation; European Central Bank, *Eligible Assets Database*; Bloomberg.

4.4 Potential Effects of the Simplified Haircut Specification

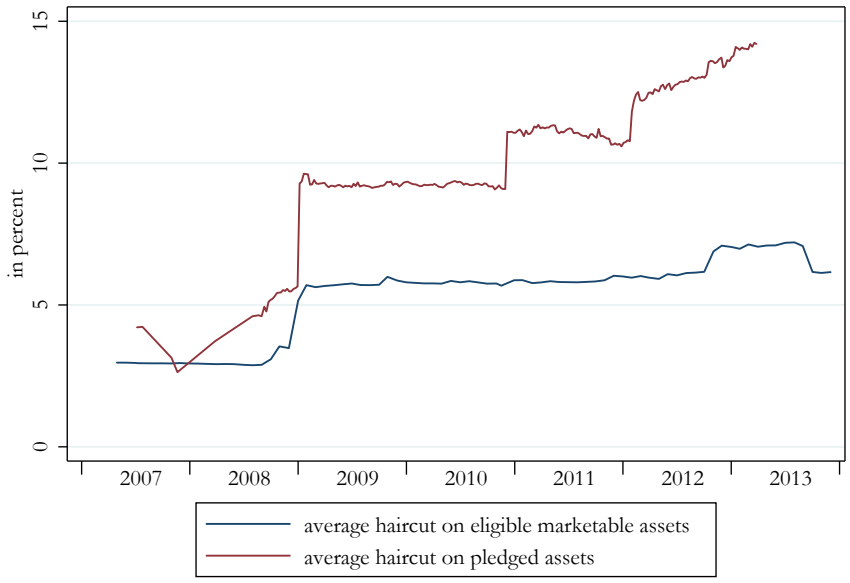
Simplified haircut specification gives rise to two potential effects. First, the Eurosystem would increase its risk exposure by lowering collateral criteria if haircuts did not fully address the

additional collateral risk. Second, simplified haircuts can lead to adverse selection of collateral, i.e. counterparties pledging assets of relatively low quality with the Eurosystem and keeping collateral of relatively good quality for alternative utilization. Therefore, the second effect fuels the first one when the Eurosystem relaxes collateral criteria and attracts assets of low quality but insufficiently hedges the additional collateral risk.

Figure 4.7 seizes upon the second potential effect of simplified haircut specification. The figure contrasts the development of the value-weighted average haircut applied to eligible marketable assets and the value-weighted average haircut imposed to collateral pledged with the Eurosystem. It reveals that the average haircut on eligible marketable assets increased from 3% in May 2007 to 6.2% in December 2013. By contrast, the increase of the average haircut on pledged collateral was considerably stronger, from 4.2% in August 2007 to 14.2% in April 2013.[157]

Figure 4.7: Average haircut to eligible marketable and pledged assets

The figure shows the development of two haircuts: first, the value-weighted average haircut applied to eligible marketable assets; and second, the value-weighted average haircut imposed to pledged assets. It reveals that average haircuts developed asymmetrically as the average haircut to pledged assets increased more than the average haircut to eligible marketable assets.



Source: author's calculation; European Central Bank, *Eligible Assets Database*; ECB 2013c.

Although both average haircuts are affected by the Eurosystem's changes to haircuts, their development was very divergent. The possible explanation for this divergent development is twofold. On the one hand, the average haircut on collateral pledged with the Eurosystem also reflects non-marketable assets that have been increasingly pledged over recent years (see Section 5.1). Given that non-marketable assets are subject to relatively large haircuts (see Section 4.2.3), their progressive pledge contributed to the increase in the average haircut. On the other hand, more assets of relatively low quality (and large haircuts) were likely pledged with the Eurosystem, owing to the adverse selection of collateral,[158] which is referred to as Gresham's

[157] See ECB 2013c for a detailed description.

[158] This view is supported by Cheun et al. 2009, Fecht et al. 2015, Nyborg 2015 and ECB 2013c, where the stronger increase of the average haircut on pledged collateral is attributed to "changes in the composition of assets used by counterparties [...]" (ibid., p. 83).

Law of Collateral (GLOC).[159] The following chapter elaborates on the adverse selection of collateral in due consideration of the simplified specification of Eurosystem haircuts.

[159] GLOC is adapted from "Gresham's law", which describes the tendency for bad money to drive out good money. For Gresham's law, see e.g. von Hayek 1976 and for GLOC, see Ewerhart et al. 2006, Chailloux et al. 2008a,b, Ewerhart and Tapking 2008, Singh 2013, Fecht et al. 2015 and in particular the following chapter.

5

Collateral Pledged with the Eurosystem[160]

This chapter investigates the effects of the development of the Eurosystem collateral framework and risk control. Specifically, the effects on the development of the quality of collateral pledged with the Eurosystem are scrutinized. Information is only published on the quantity rather than quality of pledged collateral. However, the latter is crucial as it is fundamental to the risk mitigation of the Eurosystem. Novel insights are generated based on the estimated credit quality of pledged collateral. As estimates are inter alia derived from the inferred credit quality of eligible marketable assets (Chapter 3), they are restricted to the aggregation of credit quality into CQSs. A model is elaborated that provides further indication concerning the development of collateral quality and facilitates the refinement of collateral quality to credit rating notches, i.e. the distribution of collateral within CQSs. Taking into account certain peculiarities of the Eurosystem collateral framework and risk control, the model shows that the Eurosystem is prone to adverse selection of collateral, which is referred to as Gresham's Law of Collateral (GLOC). According to GLOC, the Eurosystem likely attracts collateral of relatively low quality while good collateral is used in the repo market. Moreover, the model finds that adverse selection of collateral is intensified and beyond the control of the Eurosystem in case of positively distorted credit ratings. The chapter is structured as follows. Section 5.1 refines published information on pledged collateral, estimating how pledged collateral has shifted towards crisis-stricken countries and deteriorated in credit quality in recent years. Section 5.2 elaborates on the institutional background and analyzes collateral criteria and haircuts in the European repo market, the Eurosystem's main competitor for collateral. Section 5.3 presents the model of adverse selection of collateral. Finally, Section 5.4 revisits the development of collateral quality, taking into account the finding of adverse selection of collateral. It suggests that the risk exposure of the Eurosystem has substantially increased over recent years as collateral of low credit quality for which risk was insufficiently hedged was adversely selected to the Eurosystem.

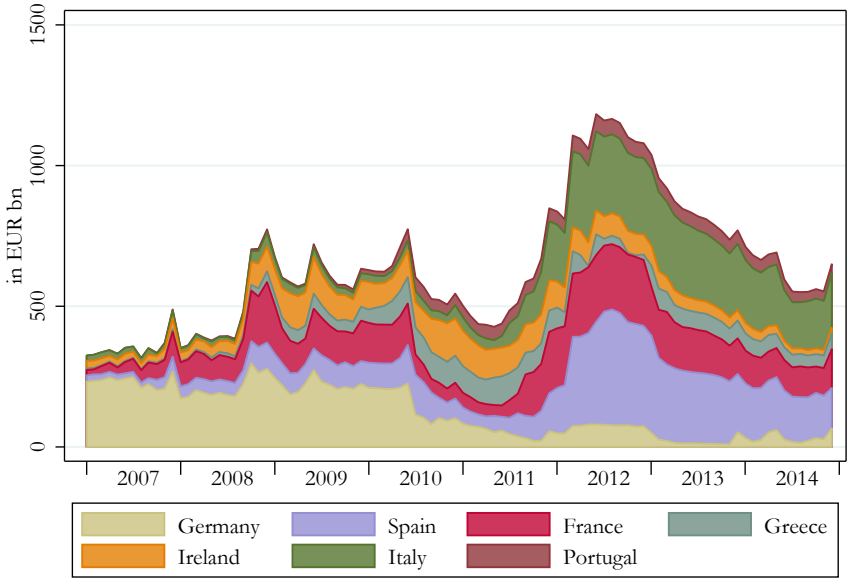
[160] Section 5.1 bases on Eberl and Weber 2015 and Sections 5.2 and 5.3 on Eberl and Weber 2013.

5.1 Development of Collateral Pledged with the Eurosystem

Refinancing credit granted by the Eurosystem has substantially changed in terms of quantity and duration, as depicted in Figure 2.5. Furthermore, Figure 5.1 shows the shift in the geographical distribution of granted refinancing credit for selected countries from May 2007 to December 2014. While the majority of refinancing credit was granted in Germany prior to the financial crisis, it shifted over time towards crisis-stricken countries where banking sectors were hit by both the financial and the sovereign debt crisis. Therefore, refinancing credit considerably changed along three dimensions, i.e. *(i)* quantity, *(ii)* duration and *(iii)* geographical distribution.

Figure 5.1: Eurosystem refinancing loans by country

The figure complements Figure 2.5 and illustrates where Eurosystem refinancing loans were accommodated, indicating a shift in the geographical distribution of refinancing loans from 2007 to 2014. While they were granted predominantly in Germany prior to the financial crisis, the majority were accommodated in Spain, France and Italy thereafter.

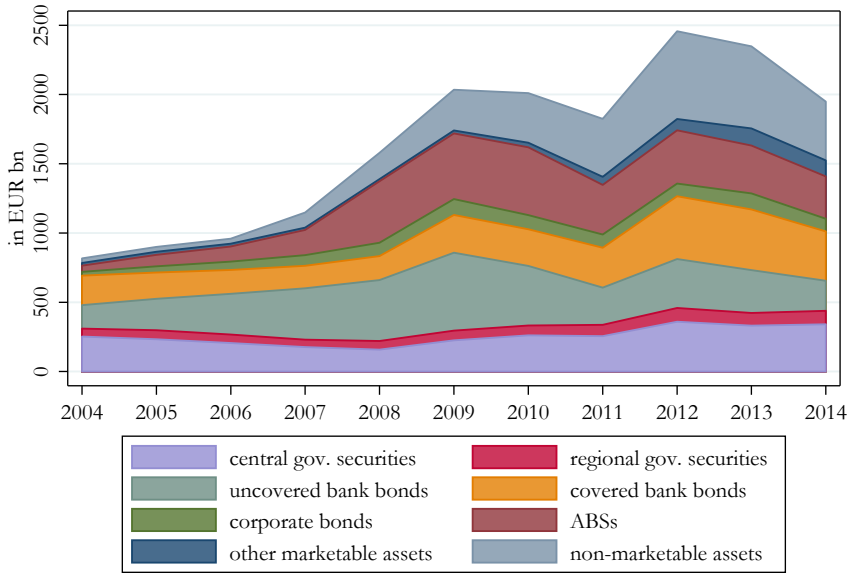


Source: author's illustration; National Central Banks.

This change in refinancing credit together with amendments to collateral criteria (see Chapter 3) suggests variation in pledged collateral, although evidence on variation is difficult to ascertain. Scarce information published by the ECB on pledged assets is illustrated in Figure 5.2 (see also ECB 2013c). Like for eligible marketable assets (Figure 3.9), the ECB only published aggregated yearly data prior to 2012 and quarterly data since then. Asset types that were increasingly pledged are uncovered bank bonds, covered bank bonds, ABSs and non-marketable assets. The substantial increase in pledge of non-marketable assets inter alia reflects the introduction of the ACCs framework in December 2011 (see Section 3.2.1). Moreover, the comparison of Figures 3.9 and 5.2 suggests that although the value of eligible government bonds increased, their pledge remained relatively stable. By contrast, ABSs were increasingly pledged although their eligible amount only slightly increased. Likewise, uncovered bank bonds were pledged to a greater extent when financial markets were under distress, which was facilitated by relaxed collateral criteria. Covered bank bonds were increasingly pledged although their eligible amount remained relatively stable.

Figure 5.2: Pledged collateral by asset type (published yearly data)

The figure details the development of pledged collateral by asset type from 2004 to 2014, based on data published by the ECB. It reveals that pledge considerably increased, in line with the expansion of refinancing loans. Increased pledge can be mainly attributed to the intensified use of bank bonds, ABSs and non-marketable assets. Owing to the restriction to yearly data (quarterly data not until 2012), insights from published data are limited.



Source: author's illustration; European Central Bank.

This is all the information that the ECB provides on pledged collateral. However, detailed information would be beneficial owing to the importance of collateral as risk hedge in case of counterparty default. Given the importance of pledged collateral yet the lack of publicly available information, the remainder of this section is devoted to elaborating additional insights into pledged collateral. Specifically, the analysis extends available information illustrated in Figure 5.2 as follows.[161] First, it disaggregates information on the yearly development by inferring from the monthly development of refinancing credit. Accordingly, the analysis provides estimates on the monthly development of pledged collateral at the country level by asset type. This facilitates identifying the country-specific effects of amendments to collateral criteria on pledged collateral. Second, the analysis generates novel information on the credit quality of pledged collateral.

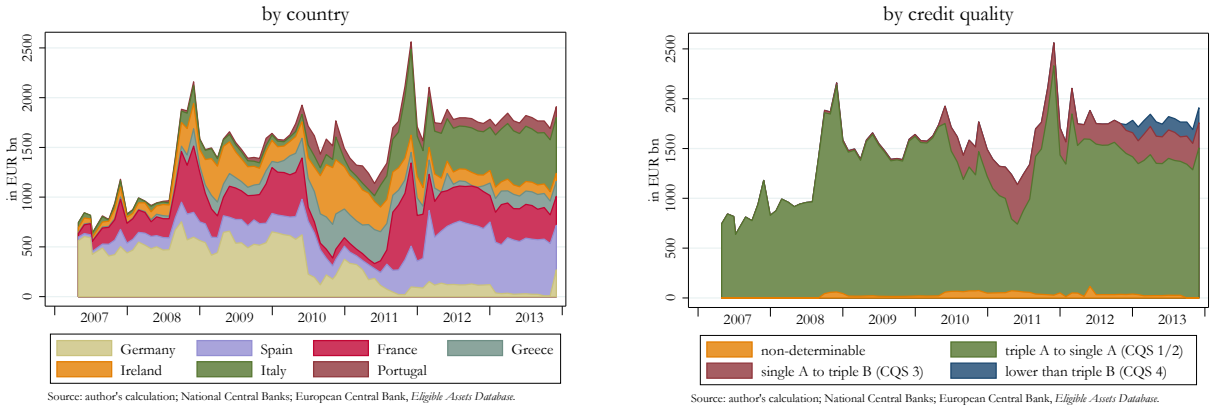
The inferred development of collateral pledged with the Eurosystem based on monthly data is depicted in Figure 5.3. It indicates large volatility across months and peaks in collateral pledge during the onset of the financial crisis (October to November 2008) and the implementation of the three-year LTROs ("big bazooka", December 2011 to March 2012). The left panel details the geographical distribution of pledged collateral and the right panel estimates its credit quality. Tautologically, the geographical distribution of pledged collateral resembles the development

[161] The analysis is performed as follows. The geographical distribution of refinancing credit is utilized to split aggregate data on pledged collateral across countries, which gives a proxy for collateral pledged at the country level. Insights into the composition of pledged collateral by asset type are gained by inferring from the composition of *(i)* national collateral pools (Figure 3.13) and *(ii)* of the Eurosystem collateral pool (Figure 3.10). The unweighted average of both is applied to reflect that collateral pledge at the country level is affected by *(i)* assets eligible in a country and *(ii)* assets eligible in other countries owing to cross-country pledge. The credit quality of pledged collateral is likewise estimated by inferring from credit quality in both *(i)* the national collateral pool (Figure 3.15) and *(ii)* the Eurosystem collateral pool (Figure 3.14). The analysis has the flaw that it cannot factor in non-marketable assets as no information is available beyond that given in Figure 5.2.

of refinancing credit (Figure 5.1). The left panel suggests that as the majority of refinancing credit was drawn in Germany prior to the crisis, the majority of collateral was also pledged there. Throughout the crisis, refinancing credit shifted towards crisis-stricken countries, as did pledged collateral. The right panel estimates that credit quality of pledged collateral was almost unaffected by the financial crisis but deteriorated throughout the sovereign debt crisis, with a considerable fraction of pledged collateral rated within CQS 3 and later also CQS 4.

Figure 5.3: Inferred pledged collateral by country and by credit quality (estim. monthly data)

The figure depicts the development of the inferred pledge of collateral by country (left panel) and credit quality (right panel) based on monthly data. The panels indicate large volatility of pledge across months, a shift in the geographical distribution and the deterioration of credit quality since the onset of the sovereign debt crisis.



Aggregate information on pledged collateral by asset type is refined to the country level in Figure 5.4. The figure suggests substantial differences across countries with respect to the types of pledged assets. In Germany, pledged collateral is estimated as having declined to almost zero throughout the sovereign debt crisis. Prior to the crisis, central government bonds and bank bonds were predominantly pledged as collateral. By contrast, pledged collateral substantially increased in Spain, particularly throughout 2010 and with the settlement of the two three-year LTROs. About one-third of initially pledged collateral was likely ABSs, although they lost importance over time owing to market developments and tighter collateral criteria. Therefore, government bonds and bank bonds grew in importance. The pledge of assets in France experienced jumps at the beginning of the financial crisis and during the implementation of the three-year LTROs. The majority of pledged collateral was likely government bonds and uncovered bank bonds. Akin, the pledge of collateral in Greece experienced a first jump with the onset of the financial crisis and substantially expanded throughout the sovereign debt crisis. Moreover, the panel reflects the phases during which the Eurosystem revoked the suspension of the minimum credit rating for collateral related to the Greek government. While government bonds accounted for the lion's share of pledged collateral in Greece, uncovered bank bonds grew in importance, especially during the course of 2013. In Ireland, pledged collateral likewise increased during two phases, i.e. throughout the financial crisis and the sovereign debt crisis. It peaked in the end of 2010 and considerably shrunk thereafter. Several types of collateral assets were likely pledged in Ireland, with ABSs playing a major role prior to the tightening of collateral criteria. Collateral pledge surged in Italy throughout 2011 and peaked during the settlement of the two three-year

LTROs. The surge can largely be referred to the pledge of central government and uncovered bank bonds. Finally, the estimated pledge of collateral in Portugal experienced a substantial increase during the sovereign debt crisis. Collateral use surged at the beginning of the crisis and dropped thereafter. Over time, government bonds accounted for the majority of collateral pledged in Portugal, although bank bonds and ABSs gained in importance.

Moreover, Figure 5.5 presents the inferred development of credit quality of pledged collateral at the country level. Figure 5.3 indicated that deterioration in the credit quality of collateral pledged with the Eurosystem intensified throughout the sovereign debt crisis. Figure 5.5 suggests that the deterioration was asymmetric across countries and the largest in countries that increasingly granted refinancing credit since the onset of the sovereign debt crisis. It indicates that credit quality remained high in Germany as well as France but slightly deteriorated in Ireland and Italy throughout the sovereign debt crisis. In Spain, credit quality decreased throughout 2012 as collateral rated within CQS 3 is estimated to have been increasingly pledged. Deterioration was the strongest in Greece and Portugal. It took place in Greece as of mid-2010 when the sovereign debt crisis emerged. Thereafter, collateral almost exclusively rated within CQS 3 is estimated to have been pledged. In 2013, the majority of pledged collateral was likely rated within CQS 4, i.e. not complying with the uniform minimum credit rating threshold for marketable assets. In Portugal, the credit quality of collateral pledged started to decline in 2011. Thereafter, about half of pledged collateral is estimated to have been rated within CQS 3.

5.2 The Repo Market as the Eurosystem's Competitor for Collateral

This section sets up the institutional background of the model presented in the next section. Section 2.3 discussed that the Eurosystem provides liquidity predominately as collateralized loans while the private provision of short-term liquidity between banks usually takes the form of repos. Although legal contracts and implementation differ between collateralized loans and repos, they are equivalent from an economic perspective and are considered as close substitutes for borrowers such that the Eurosystem and the repo market are in competition for collateral. The following section addresses general aspects of repos and provides a brief overview of collateral criteria and risk mitigation in the European interbank repo market. Furthermore, similarities and distinctions between private repos and collateralized loans by the Eurosystem are carved out.

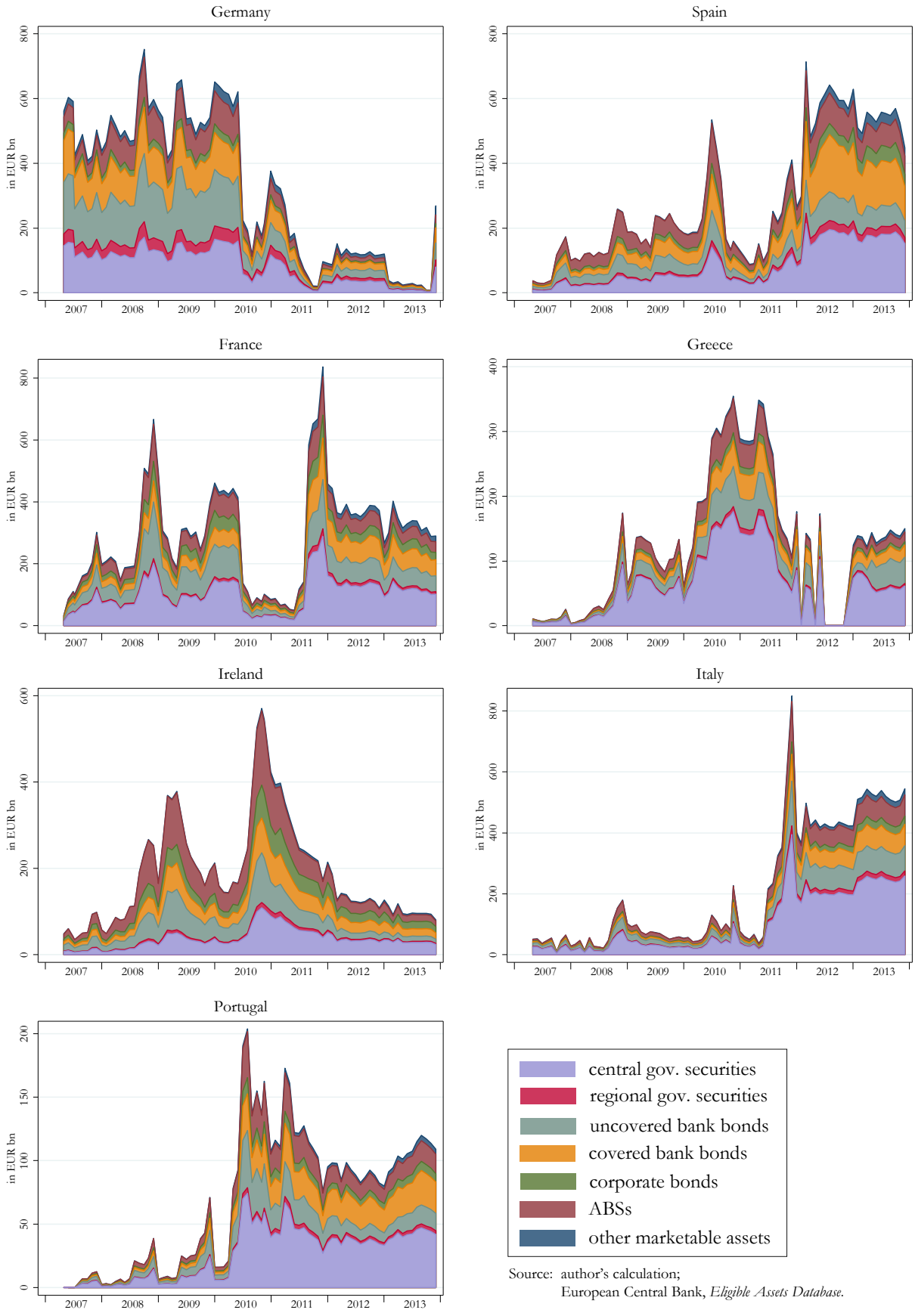
5.2.1 General Aspects of Repurchase Agreements

A repo is an agreement between two parties in which one party sells assets to the other and simultaneously agrees to buy back the assets at a later date.[162] The repurchase price usually exceeds the purchase price such that the difference can be regarded as equivalent to the interest paid in collateralized lending.

[162] Therefore, one party is usually called the seller/borrower/collateral provider (COP) and the other is referred to as the buyer/lender/cash provider (CAP).

Figure 5.4: Inferred collateral pledged at the country level by asset type

The figure refines aggregate information on inferred pledged collateral by asset type to the country level, suggesting substantial differences in the types of pledged assets across countries.



Source: author's calculation;
European Central Bank, *Eligible Assets Database*.

Repos hold interest for two reasons. First, they are the main instrument for short-term bank funding (cf. ECB 2012b, 2014c). In December 2014, the total value of contracts outstanding in the European repo market was estimated at EUR 5.5 tn, having slightly declined from EUR 5.8 tn in June 2014 (cf. ICMA 2014). These figures do not include the value of repos transacted with the Eurosystem or central banks outside the Eurosystem. Accordingly, the majority of the repos were performed in the interbank market.[163] Second, the Eurosystem carries out a fraction of its liquidity-providing operations via repos as one of two possible types of reverse transactions (cf. Section 2.1). Therefore, repo markets occupy first-order relevance for the Eurosystem's refinancing operations.[164]

There are different reasons for both the lender and the borrower to enter a repo.[165] In general, the interbank repo market allows liquidity-seeking banks to receive funding from banks with excess liquidity. Borrowers can use idle assets to finance long positions while lenders are able to cover short positions. Interest cost are usually low as repo markets feature high market liquidity. For banks with excess liquidity, repos thus reflect an additional investment option that implies relatively small risk owing to short duration and collateralization ("cash-driven" motive). Moreover, the motive for entering a repo can also be for borrowing certain collateral assets ("security-driven"). Consequently, collateral assets are usually specific in security-driven repos, while cash-driven repos are often conducted as general collateral (GC) repos. In GC repos, lenders accept as collateral a basket/range of assets (i.e. a specific asset type or a specified list of ISIN codes) provided that the assets meet requirements on e.g. credit quality. Security-driven repos are usually referred to as "specials" and no prior restrictions on collateral assets are made.

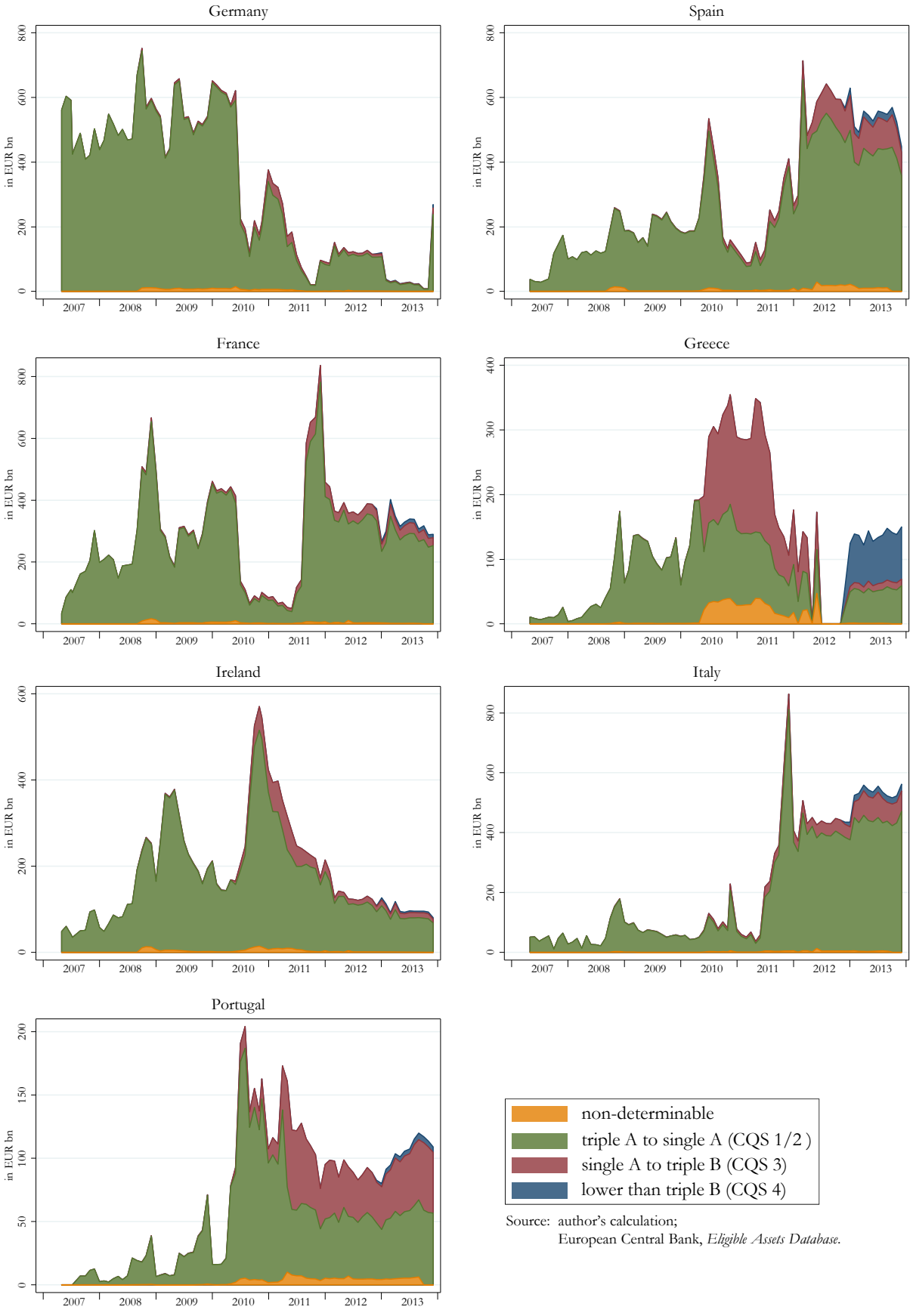
The following two processes within repo transactions hold interest for the analysis at hand as they are decisive for the specification of collateral criteria and risk control, i.e. *(i)* the management of collateral and *(ii)* the clearing of delivery and payment obligations.[166]

Collateral Management At the level of collateral management, securities are valued, selected and delivered as collateral from the borrower to the lender. This is undertaken either bilaterally, i.e. by counterparties themselves ("bilateral") or under the involvement of a third party, usually a custodian bank ("tri-party"). Throughout the repo transaction, functions related to collateral management also involve maintaining collateral value and quality. Irrespective of whether collateral management is bilateral or tri-party, collateral risk remains with the lender as the third party does not assume any risk. Repos in which a third party manages collateral are usually cash-driven as the lender and the borrower only negotiate repo conditions but not the delivery of specific collateral assets.

[163] Cf. Bakk-Simon et al. 2012. For a detailed investigation of the European interbank repo market, see ECB 2014d as well as Mancini et al. 2015.
[164] See BIS 1999 for an early description of the repo market from the perspective of central banks.
[165] For an extensive description of these reasons, see e.g. Choudhry 2006.
[166] Trading and settlement are two further processes in repo transactions. See e.g ECB 2013a for further details.

Figure 5.5: Inferred collateral pledged at the country level by credit quality

The figure generates new information on inferred pledged collateral by investigating the credit quality of pledged collateral at the country level, indicating that it developed asymmetrically across countries.



Source: author's calculation;
European Central Bank, *Eligible Assets Database*.

Clearing At the clearing level, delivery and payment obligations are netted among lenders and borrowers.[167] Clearing is performed either bilaterally or multilaterally: in the former, each lender/borrower nets obligations separately with each borrower/lender, while in the latter a CCP interacts between the lender and the borrower and nets obligations. The CCP also becomes the buyer and seller, respectively, of collateral, once the transaction has been agreed between the lender and the borrower. Therefore, the CCP becomes the counterparty to both parties of the repo, i.e. the borrower to the lender and the lender to the borrower, respectively. Repo contracts not cleared by a CCP are less standardized with respect to both collateral requirements and contract terms. However, CCP-cleared repos are usually advantageous to both the lender and the borrower as the CCP is usually a AAA-rated agency and protects both from counterparty default.[168] Furthermore, risk exposure is reduced as the CCP nets transactions between counterparties on a multilateral basis, which implies a smaller net exposure between counterparties relative to non-CCP clearing. The motivation for lenders to enter CCP-cleared repos is usually cash-driven, while it is often security-driven in non-CCP-cleared repos as the smaller degree of standardization allows collateral to be more specific. Table 5.1 details the possible combinations of clearing and collateral management and it is indicated who specifies collateral criteria and imposes the haircut.

Table 5.1: Combinations of clearing and collateral management in private repos

The table details the possible combinations of clearing and collateral management. Combinations are vital for who is exposed to collateral risk, hence specifying collateral criteria and the haircut.

		Collateral Management	
		Bilateral	Tri-Party
Clearing	CCP	collateral criteria and haircut imposed by *CCP*	collateral criteria and haircut imposed by *CCP*
	Non-CCP	collateral criteria and haircut imposed by *lender*	collateral criteria and haircut imposed by *lender*

Source: author's compilation.

Risk Mitigation through Collateralization and Haircuts Analogous to the Eurosystem, lenders in the repo market hedge risk in two steps: first, collateral is taken to hedge risk of borrower default (counterparty risk); and second, haircuts are applied to mitigate risk associated with collateral (collateral risk).[169] The eligibility of collateral in the repo market is usually restricted to bonds and other fixed-income instruments and haircuts are applied to the market value of the collateral to mitigate the risk associated with liquidation in case of counterparty default. Table 5.1 reveals that lenders determine eligibility requirements and haircuts applied to col-

[167] Clearing refers to several activities in between trading and settlement, namely trade capture, trade verification, trade matching or affirmation, legal confirmation, reporting to a trade repository, position and payment netting, portfolio compression, novation (a central clearing mechanism) and risk management (cf. ECB 2013a).

[168] CCPs are AAA-rated as exposure is strictly collateralized, backed by reserves and further safeguards like default funds.

[169] Gorton and Metrick 2010, 2012 empirically analyze evolutions in the US repo market throughout the financial crisis. The studies find that haircuts significantly increased from essentially zero in the process of deleveraging, which is referred to as a "run on repo". Further studies on the development of repo markets and haircuts during and after the financial crisis include Brunnermeier 2009 and Krishnamurthy et al. 2014.

lateral in non-CCP-cleared repos irrespective of whether a third party is involved in collateral management. The third party only manages collateral but does not assume any responsibility for it. Thus, risk mitigation is crucial for the lender as he would be left with any loss in case of borrower default. By contrast, in CCP-cleared repos, the CCP buys the collateral and also imposes requirements and haircuts to the collateral. Hence, haircuts are exogenous to lenders in CCP-cleared repos.

5.2.2 Collateral and Haircuts in the European Repo Market

The Eurosystem competes for collateral with private lenders that participate in the European repo market. The total value of repo contracts outstanding in this market amounted to EUR 5.5 tn in December 2014, compared to EUR 0.63 tn of outstanding refinancing credit from the Eurosystem (cf. ICMA 2014 and Section 2.1).[170] The following collects the scarce available information on the European repo market in terms of collateral and haircuts.

Collateral

The geographical distribution of collateral sold in the European repo market is illustrated in Figure 5.6.[171] It indicates the development of the value of outstanding repos and shows that the fraction of assets used for repos in Germany, Spain, France, Greece, Ireland, Italy and Portugal (where the vast majority of collateral that the Eurosystem receives is pledged) slightly declined over time, i.e. from 56.7% in June 2007 to 48.1% in December 2014. Most of this collateral was sold in Germany, France, Italy and Spain, while only negligible amounts were pledged in Greece, Ireland and Portugal.

In order to gain further insights, the European repo market is segmented along the lines of Table 5.1, i.e. with respect to clearing (CCP-cleared vs. non-CCP-cleared) and collateral management (bilateral vs. tri-party), as additional information is available for CCP-cleared and tri-party repos. The terms of non-CCP-cleared and bilateral repos are usually negotiated directly between counterparties with no information being made available.

According to ibid., 27.4% of repo contracts were cleared with CCP-involvement in 2014.[172] Clearing services in the European repo market were mainly provided by five CCPs by the end of 2014, i.e. CC&G in Italy, BMEClearing in Spain, LCH-Clearnet SA in France, LCH-Clearnet Ltd in the UK, and Eurex Clearing in Germany. Owing to this geographical segmentation and potential differences in risk preference, CCPs deemed eligible different types of collateral. CC&G accepted government bonds from Germany, France and Italy. BMEClearing deemed eligible a variety of securities and government bonds from Austria, Belgium, France, Germany, the Netherlands, Spain, the UK and the US. For LCH-Clearnet SA, government bonds from inter

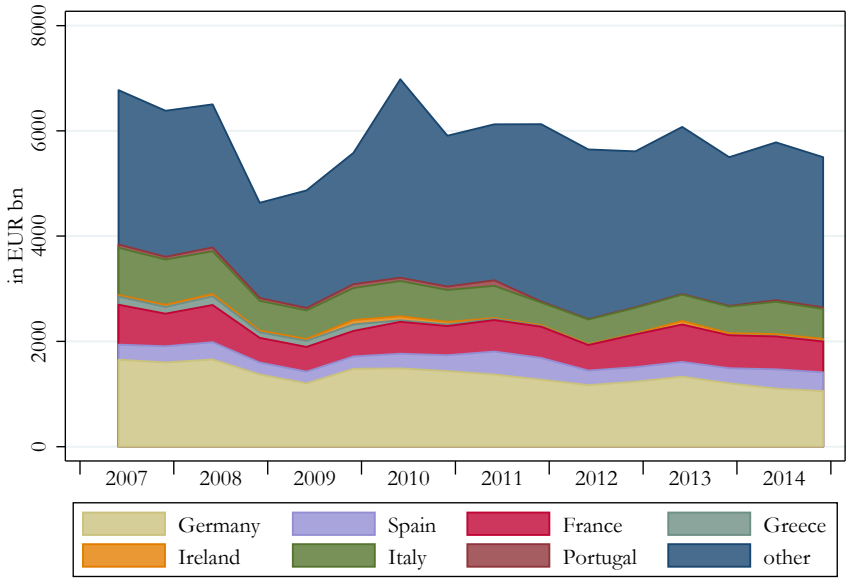
[170] For the following indicative analysis of the European repo market, the series of the International Capital Market Association (ICMA) repo market survey is consulted. See ICMA 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014.

[171] Analogous to above, the geographical distribution is considered in terms of the country where collateral was issued.

[172] Therefore, the vast majority of repos (72.6% worth EUR 4 tn in 2014, cf. ICMA 2014) was contracted without CCP-involvement. In these repos, contractual details are negotiated bilaterally and no a priori restrictions on collateral are made.

Figure 5.6: Collateral pledged in the European repo market by country

The figure elaborates on the geographical distribution of collateral pledged in the European repo market and shows that the fraction of collateral from Germany, Spain, France, Greece, Ireland, Italy and Portugal (where the Eurosystem receives the lion's share of pledged collateral) slightly declined over time.



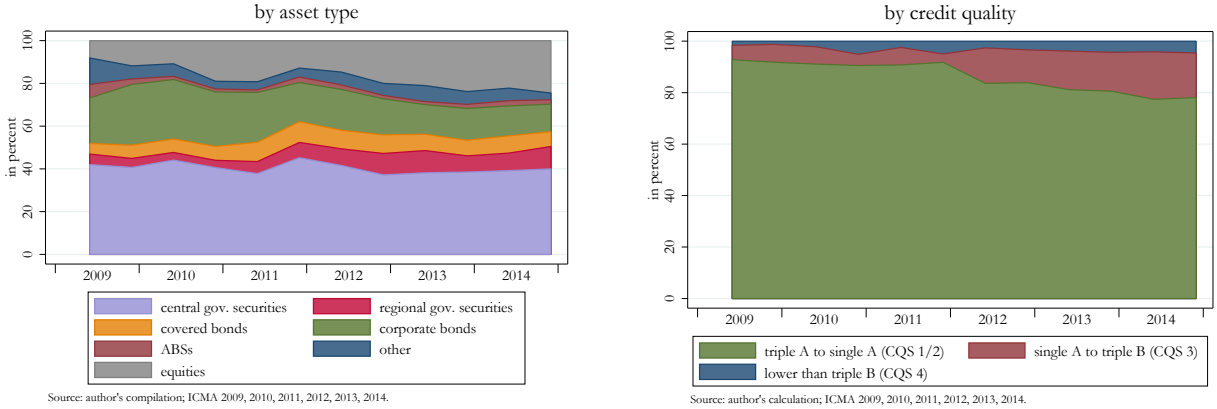
Source: author's compilation; ICMA 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014.

alia Belgium, France, Germany, Italy, the Netherlands, Portugal, Spain, the UK and the US were eligible, as well as government-guaranteed bonds. Likewise, LCH-Clearnet Ltd embraced a variety of government bonds, from e.g. Austria, Belgium, Finland, Germany, Ireland, the Netherlands, Portugal, Slovakia, Slovenia, Spain and the UK. In addition, it deemed eligible corporate bonds that were rated above "single A". Finally, Eurex approved a broad variety of fixed-income securities such as government bonds denominated in euro, Swiss francs as well as other currencies. Moreover, it accepted equities denominated in euro and Swiss francs.

For the tri-party segment of the European repo market, information is available on the type and credit quality of traded collateral. Tri-party repos are contracted directly between the two parties as the involved third party undertakes collateral management but does not assume any risk. International Capital Market Association 2014 reports that 10.5% of contracts in the European repo market in 2014 were tri-party, having slightly increased over recent years. The development of the type and credit quality of collateral in tri-party repos is depicted in Figure 5.7 from June 2009 to December 2014. The left panel reveals that government bonds, corporate bonds and equities are predominantly sold in tri-party repos. Regional government bonds and equities replaced corporate bonds over time. While these corporate bonds may instead have been pledged with the Eurosystem (cf. Figure 5.3), equities have been deemed ineligible as collateral by the Eurosystem as of May 2005 (cf. Section 3.2.1). The right panel indicates the credit quality of pledged assets (aligned to the Eurosystem's understanding of credit quality) and shows that it remained relatively high, with about 80% to 90% of all assets rated within CQS 1/2.

Figure 5.7: Collateral pledged in tri-party repos by asset type and by credit quality

The figure illustrates the development of the composition of collateral pledged in tri-party repos from 2009 to 2014 by asset type (left panel) and credit quality (right panel). The left panel reveals that government bonds, corporate bonds and equities were predominantly pledged in tri-party repos. The right panel indicates that credit quality of pledged assets deteriorated from June 2009 to December 2014.



However, comparing the development of collateral credit quality in tri-party repos and with the Eurosystem (Figure 5.3) reveals differing developments. In June 2009, 92.8% of collateral pledged in tri-party repos was rated within CQS 1/2 while 97.7% of collateral pledged with the Eurosystem is estimated to have been of such high quality. Credit quality deteriorated both in the repo market and with the Eurosystem over time, although the decline was likely stronger for the Eurosystem than in tri-party repos. At the end of 2013, only 78.9% of collateral pledged with the Eurosystem was likely still rated within CQS 1/2 compared to 80.5% in the repo market.[173]

Haircuts

According to Table 5.1, haircuts are imposed by CCPs in CCP-cleared repos but bilaterally negotiated otherwise. In accordance with the European Market Infrastructure Regulation (EMIR), CCPs are required to apply haircuts that are regularly tested (and revised if necessary) and take market conditions into account (European Parliament 2012). Haircuts have to be determined individually for each collateral asset, considering its relevant properties such as its type and credit quality.[174] Available information on haircuts applied in private repos is scarce, with the little indicative evidence suggesting that haircuts depend on the type of the repo, i.e. whether the repo is GC or special (see above). In certain GC repos (e.g. Eurex Repo Euro GC Pooling, LCH.Clearnet Ltd's RepoClear €GC), haircuts (and collateral criteria in general) are assumed from the Eurosystem. In less standardized CCP-cleared repos, CCPs impose own haircuts. For instance, BMEClearing states that it applies a "minimum haircut, equal to that of the ECB [...]", which is increased if deemed necessary.[175] Table 5.2 compares average haircuts applied to selected government bonds from January 2011 to December 2013 by two CCPs and

[173] Section 5.3 offers a potential explanation for this indicative evidence of adverse selection of collateral based on the peculiarities of the Eurosystem collateral framework and risk control.

[174] Other properties are legal risk, operational risk, duration, historical and hypothetical future price volatility (manifested in liquidity risk), wrong-way risk and exchange-rate risk. See Section 4.2.1 and e.g. ECB 2013a.

[175] Cf. BMEClearing, "Collateral Valuation," `http://www.bmeclearing.es/ing/Collateral/CollateralProcessing.aspx`.

the Eurosystem.[176] The table reveals that the average haircut of the Eurosystem was always lower than that applied by CCPs. Haircut determination by CCPs may also be more differentiated. For instance, CC&G differentiated haircuts according to eleven clusters of residual maturity for Italian government bonds but only for four clusters in case of French or German government bonds. LCH-Clearnet SA used nine clusters of residual maturity for determining haircuts on the variety of government bonds that it accepted.

Table 5.2: Haircuts applied to selected government bonds by CCPs and the Eurosystem

The table compares the average haircut applied to selected government bonds of different residual maturity between January 2011 and December 2013 by two CCPs and the Eurosystem, revealing that average haircuts of the Eurosystem fell short of CCPs' average haircuts for all considered government bonds.

	Duration	BME[a]	CC&G[a]	Eurosystem[a]
Germany	Short[b]	2	3.86	0.5
	Middle[c]	3.56	7.72	2.42
	Long[d]	7.65	20	5.46
France	Short[b]	2	3.86	0.5
	Middle[c]	3.56	3.86	2.42
	Long[d]	7.65	7.72	5.46
Italy	Short[b]	n/a[e]	5.95	0.5
	Middle[c]	n/a[e]	13.45	2.42
	Long[d]	n/a[e]	22.51	5.46
Spain	Short[b]	2	n/a[e]	0.5
	Middle[c]	3.56	n/a[e]	2.42
	Long[d]	7.65	n/a[e]	5.46

[a] In percentage points.
[b] Defined as a government bond with residual maturity of less than 6 months.
[c] Defined as a government bond with residual maturity of 4 years.
[d] Defined as a government bond with residual maturity of 11 years.
[e] Not available as deemed ineligible.
Source: author's compilation; CCPs; European Central Bank.

This indicative evidence suggests that while a broad range of collateral is deemed eligible in both the (different segments of the) repo market and by the Eurosystem, contract conditions such as haircuts may differ. This was discussed for CCP-cleared repos. However, it is intuitive that conditions also differ between non-CCP cleared repos and collateralized loans from the Eurosystem. In these repos, haircuts are subject to negotiation between the lender and the borrower and contracted over the counter in almost three-quarters of repo transactions (ICMA 2014), which makes available data and information very scarce.

Different conditions in private repos and collateralized loans from the Eurosystem are at the heart of the model presented in the following section, investigating the decision of a borrower seeking liquidity either in the repo market or from the Eurosystem. Hence, it applies to all borrowers that have discretion to pledge collateral in the market or with the Eurosystem. Applicability may be limited if a borrower does not have this discretion owing to e.g. counterparty ineligibility (e.g. the borrower is not deemed eligible by the Eurosystem) or collateral ineligibility (e.g. the

[176] See also ECB 2014a for a further comparison of haircuts applied by CCPs and the Eurosystem.

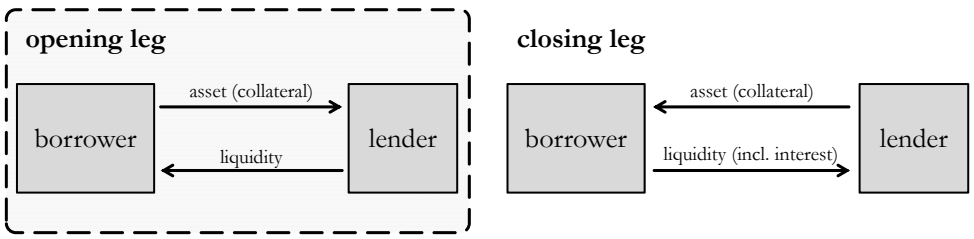
collateral is deemed ineligible by the Eurosystem). However, this limitation is de facto loose since the Eurosystem lends to a broad range of counterparties against an ever-broader range of collateral (Chapter 3).

5.3 Gresham's Law of Collateral: A Model of Adverse Selection of Collateral

This section presents a model that elaborates on the behavior of liquidity-seeking banks. Banks can draw this liquidity by borrowing either in the market ("private liquidity") or from the Eurosystem ("public liquidity"). It was discussed above that repos and collateralized loans are equivalent from an economic perspective. Therefore, no distinction is made between the specifics of liquidity provision in the market and by the Eurosystem, which is modeled as repos. The model builds upon the course of action of a repo stylized in Figure 5.8, which depicts the decomposition of a repo into two transactions taking place at distinct points in time, i.e. the opening leg and the closing leg. Within the opening leg, the lender and the borrower agree on the repo as well as its conditions and transfer liquidity in exchange for collateral. Within the closing leg, the borrower repurchases the collateral from the lender and the lender receives back the provided liquidity together with interest implied in a potentially higher repurchase price.

Figure 5.8: Stylized course of action for a repo

The figure stylizes the course of action for a repo and depicts its decomposition into two transactions taking place at distinct points in time, i.e. the opening leg and the closing leg. The following analysis focuses upon the opening leg.



Source: author's illustration.

The model focuses upon the opening leg and the borrower's decision to enter a repo with either another bank ("private lender") or the Eurosystem ("public lender"). Repo terms are shaped by six determinants (see Section 2.3): *(i)* maturity, *(ii)* interest rate, *(iii)* counterparty, *(iv)* amount, *(v)* collateral and *(vi)* haircut. To analyze the decision of the borrower along one dimension, determinants *(i)* to *(v)* are assumed to be equal in private and public repos, which makes the haircut the crucial determinant. Specifically, this means that *(iii)* any bank can borrow *(iv)* the same amount of liquidity for *(i)* the same period against *(ii)* the same interest rate and *(v)* the same collateral in the market or from the Eurosystem. Therefore, the borrower's decision solely depends on the comparison of the haircut offered in private (in the market) or public (with the Eurosystem) repos.

Lenders impose a haircut to mitigate collateral risk such that the haircut size reflects expectations about the collateral liquidation value. In a certain world, the lender would not bear a loss from borrower default as it would be fully anticipated. The repo would be fully collateralized

and the lender would not be worse off from liquidating collateral. However, in reality, borrower default could imply a loss to the lender as expectations about the liquidation value may be incorrect, leading to an under-collateralized repo. Risk mitigation is carried out in the opening leg based on expectations about the collateral liquidation value. The actual outcome of the repo in the closing leg, i.e. whether or not the asset is repurchased, is of second-order as expectations of this outcome are reflected in repo terms realized in the opening leg. Hence, the analysis is narrowed to the opening leg without loss of generality.

The model elaborates on the adverse selection of collateral, which is often referred to as "Gresham's Law of Collateral" (GLOC) in the literature. GLOC is adapted from "Gresham's law", which describes the tendency for bad money to drive out good money. Accordingly, if coins contained metal of different value yet had the same value as legal tender, the coins comprising the cheaper metal ("bad money") would be used for payments while the coins made of the more expensive metal ("good money") would be hoarded (see e.g. Macleod 1856 and von Hayek 1976). The analogy between Gresham's law for specie and for collateral was established narratively by Chailloux et al. 2008a,b and addressed as the risk of adverse selection of collateral in Singh 2013. The adverse selection of collateral was first technically analyzed by Ewerhart et al. 2006, who suggest borrowers' preference to pledge illiquid collateral with the central bank owing to different pricing of liquidity risk by the private market and the central bank. Ewerhart and Tapking 2008 provide support that the least liquid and most risky assets are deposited with the central bank, while higher-quality assets are pledged in private (bilateral) repos as this alleviates two-way credit risk. Bindseil 2014 seizes on the phenomenon of GLOC and discusses four measures that central banks could in principle consider to counteract the concentration of bad collateral owing to adverse selection. Most recently, Fecht et al. 2015 document adverse selection (referred to as "systemic arbitrage") for German banks' borrowing from the Eurosystem over the 2006-2010 period. In this context, systemic arbitrage is also addressed in Nyborg 2015. The following model differs from previous analyses as it addresses GLOC specifically for the Eurosystem based on the peculiarities of the Eurosystem collateral framework and risk control. Moreover, it emphasizes the role of rating agencies for the degree of adverse selection.

The elaboration of the model is structured as follows. First, the basic model with symmetric information is set up as the benchmark. Subsequently, asymmetric information, a signal of collateral quality and an outside option to borrowers are introduced. The outside option is then further specified and modeled as a stylization of repo condition offered by the Eurosystem in terms of pooling of repo conditions.

5.3.1 Model with Private and Public Liquidity Provision

In the basic model, only the repo market is considered and counterparties can interact in the following simple way: liquidity-seeking banks can use bonds in repos with banks that have excess liquidity. In this environment, four steps of analysis will be taken in which the information structure and the involved players differ. First, borrowers and lenders are symmetrically informed about the quality of bonds that can be used as collateral. Second, the case is considered in

which the borrower has more information than the lender about collateral quality (asymmetric information). Third, the impact of credit ratings as a signal on collateral quality is evaluated. Fourth, an outside option for borrowers is introduced, i.e. the possibility to use collateral outside the repo market, e.g. with the central bank as public lender.

5.3.1.1 Model Setup[177]

There are J profit-maximizing borrowers who own one collateral asset each, e.g. a bond. The initial cost of bond creation is assumed to be zero. Bonds differ in the level of quality θ such that bond j is of (unique) quality θ_j, which can be thought of e.g. higher credit quality or liquidity of bond j.[178] Quality is uniformly distributed in the range between the lowest $\underline{\theta}$ and the highest quality level $\bar{\theta}$, i.e. $\theta_j \in [\underline{\theta}, \bar{\theta}] \subset \mathbb{R}$. Different quality levels emerge as risk-to-return ratios of assets underlying the bonds differ such that $0 < \underline{\theta} < \bar{\theta} < \infty$. Selling the bonds gives borrowers liquidity that can be used e.g. to make new loans resulting in a positive return.

Risk-neutral lenders purchase bonds under perfect competition at price $\rho(\theta_j)$. The purchase price is equal to the haircut-adjusted market value of the bond, i.e. $(1 - h_L(\theta_j))\Omega(\theta_j)$, with $0 \leq h_L(\theta_j) \leq 1$ being the haircut that a lender applies to the market value $\Omega(\theta_j)$ of bond j with quality θ_j.[179] Lenders seek to maximize profit and use an identical production function yielding constant returns to scale with bonds being the only input. For simplicity, each bond generates output equal to θ_j, which can be regarded as return on investment (depending on the quality of the bond), assuming the absence of production costs. The price that lenders take on their output is equal to unity such that their earnings also equate to θ_j.

5.3.1.2 Symmetric Information

If lenders and borrowers both have complete information about the quality of each bond, lenders will offer to pay distinct prices equal to quality $\rho(\theta_j) = \theta_j$. This is what lenders earn from owning the bond and owing to the competitive structure on the demand side, it also gives the equilibrium price. As borrowers miss alternative utilization of the bonds, the set of marketing borrowers is given by $\Theta(\rho) = \{\theta_j : 0 \leq \rho(\theta_j)\}$. As $\rho(\theta_j)$ is equal to θ_j and $\underline{\theta}$ is strictly positive, the set comprises all J borrowers. All bonds are traded and aggregate surplus in the repo market (defined as the sum of rents of borrowers and lenders) is maximized. Figure 5.9 provides a graphical illustration of the equilibrium with symmetric information. Bond quality θ runs on the horizontal axis, with the relevant quality range indicated by $\underline{\theta}$ and $\bar{\theta}$. The 45°-line maps bond quality onto the vertical axis as quality θ_j equals output net of cost and hence earnings from the bond to a lender who is willing to pay a price of the same amount. Therefore, the price is given on the vertical axis. As each bond is traded at a price equal to its quality level, lenders are left with zero rent. Payments to borrowers are reflected by the area underneath the

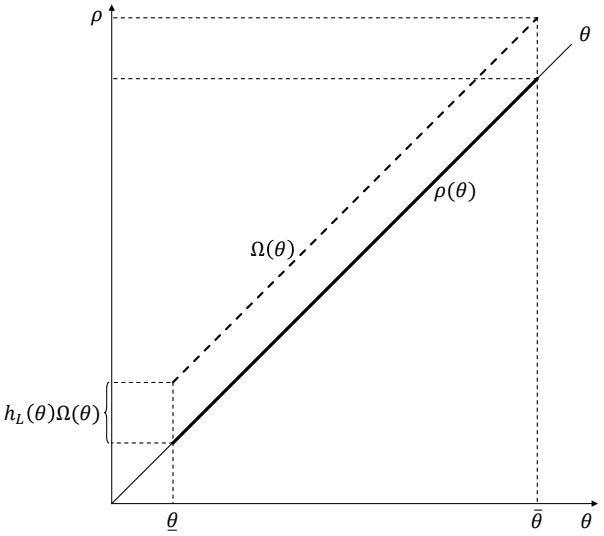
[177] The model setup bases on Mas-Colell et al. 1995.

[178] Hence, θ represents a broad argument of collateral quality, i.e. it can be interpreted as reflecting collateral success probability q or liquidity κ.

[179] This haircut-adjusted market value will later be referred to as private collateral value, i.e. the value that private lenders assign to collateral.

price curve in the range between $\underline{\theta}$ and $\bar{\theta}$. The area gives aggregate surplus in this market and corresponds to the rent of the supply side, i.e. borrowers.

Figure 5.9: Equilibrium with symmetric information



Source: author's illustration.

Technically, rent distribution can be formulated as follows. Lenders are left with zero rent, i.e. $R_L = 0$, while each borrower receives $\rho(\theta_j)$ in exchange for collateral, has zero cost and all bonds are traded such that[180]

$$R_B = \frac{\bar{\theta}^2 - \underline{\theta}^2}{2} \tag{5.1}$$

is the rent of borrowers. Aggregate surplus R in the market is equal to the rent of borrowers as R_L is equal to zero, i.e. $R = R_B = \frac{\bar{\theta}^2 - \underline{\theta}^2}{2}$.

5.3.1.3 Asymmetric Information

In the next step, lenders cannot observe the quality of the bond that they purchase (asymmetric information). Rather than distinct prices equal to bond quality, lenders offer the uniform price $\rho(\theta_j) = \rho \; \forall \; \theta_j$. As borrowers still lack an alternative to selling bonds on the market, they accept any non-negative price. Accordingly, the set of marketing borrowers is given by $\Theta(\rho) = \{\theta_j : 0 \leq \rho\}$. Lenders' demand for bonds ζ is a function of ρ and can be expressed as

$$\zeta(\rho) = \begin{cases} 0 & \text{if } \mu < \rho; \\ [0, \infty) & \text{if } \mu = \rho; \\ \infty & \text{if } \mu > \rho, \end{cases} \tag{5.2}$$

with μ representing the lenders' uniform belief concerning the average quality of traded bonds. Figure 5.10 illustrates the market with asymmetric information. Lenders anticipate that at any non-negative price, $\Theta(\rho)$ comprises all J borrowers and all bonds in the range from $\underline{\theta}$ to $\bar{\theta}$ are marketed. Lenders' belief concerning the average bond quality in the market, i.e. the expected

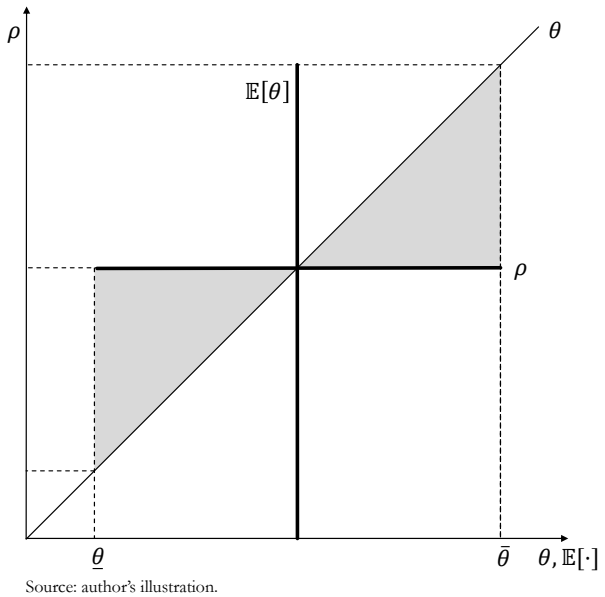
[180] See the appendix for the derivation of Equation (5.1).

bond quality, is given by $\mu = \mathbb{E}[\theta|\theta \in \Theta(\rho)] = \frac{\bar{\theta}+\underline{\theta}}{2}$ as θ is uniformly distributed within $[\underline{\theta}, \bar{\theta}]$. Lenders are in perfect competition for bonds and offer a price that simply reprieves them from an expected loss such that $\rho = \frac{\bar{\theta}+\underline{\theta}}{2}$. While some lenders realize profits and others lose, lenders overall are still left with zero rent, i.e. $R_L = 0$. Therefore, the rent of borrowers is equal to aggregate surplus in the market, amounting to[181]

$$R_B = R = \frac{\bar{\theta}^2 - \underline{\theta}^2}{2}. \tag{5.3}$$

Figure 5.10 shows the expenditure of lenders by the rectangle under the horizontal price line (between $\underline{\theta}$ and $\bar{\theta}$), which is also what borrowers receive as payment for their bonds, i.e. their rent R_B. The earnings of borrowers correspond to the area below the 45°-line (between $\underline{\theta}$ and $\bar{\theta}$). The rents of borrowers and lenders are equal to the benchmark case of symmetric information, as is the aggregate surplus R. However, there are important differences with respect to the distribution of rents within the groups of lenders and borrowers. On the one hand, lenders purchasing (without knowing) bonds of relatively low quality of up to $\frac{\bar{\theta}+\underline{\theta}}{2}$ take losses, as illustrated by the left shaded triangle. This is because they pay the uniform price $\rho = \frac{\bar{\theta}+\underline{\theta}}{2}$ but receive bonds of quality $\theta_j < \frac{\bar{\theta}+\underline{\theta}}{2}$. On the other hand, lenders purchasing higher-quality bonds, $\theta_j > \frac{\bar{\theta}+\underline{\theta}}{2}$, receiving profits that correspond to the right shaded triangle. Only the lender who receives the bond of quality $\theta_j = \frac{\bar{\theta}+\underline{\theta}}{2}$ for paying $\rho = \frac{\bar{\theta}+\underline{\theta}}{2}$ makes zero profit, like all lenders did with symmetric information. As the shaded triangles offset in aggregate, R_L remains unaffected. Likewise, borrowers are affected by asymmetric information. Those borrowers selling bonds with $\theta_j < \frac{\bar{\theta}+\underline{\theta}}{2}$ receive a higher price than with symmetric information, while borrowers with $\theta_j > \frac{\bar{\theta}+\underline{\theta}}{2}$ are worse off. Accordingly, rent is redistributed from borrowers with high-quality bonds to those with low-quality bonds. Asymmetric information leads to redistribution within the group of lenders and borrowers while aggregate surplus is still maximized.

Figure 5.10: Equilibrium with asymmetric information



Source: author's illustration.

[181] See the appendix for the derivation of Equation (5.3).

5.3.1.4 Signaling under Asymmetric Information

Each lender is now supposed to observe a signal $s(\theta_j)$ on the quality θ of bond j that ranges between $[\underline{\theta}, \bar{\theta}]$. Each lender is assumed to believe in this signal as it provides information on bond quality which the lender would otherwise not have. For instance, this signal could be interpreted as a credit rating by a rating agency that is able to assess bond quality.[182] Technically, lenders' belief on bond quality is conditional on the signal and given by $\mathbb{E}[\theta_j|s(\theta_j)] = s(\theta_j)$. Obviously, if the signal reflects true quality, i.e. $s(\theta_j) = \theta_j \; \forall \; \theta_j$, asymmetric information would be resolved and the outcome under symmetric information would be mimicked. There are at least three possible explanations for a distorted signal. First, although the rating agency may have the necessary information available to correctly assess bond quality, it delivers a rating that does not fully reflect this information.[183] Second, borrowers who have to acquire the ratings may selectively disclose ratings, i.e. only disclosing the best rating available. This "ratings shopping" was observed prior to the financial crisis, especially for complex securities.[184] Third, the rating agency may systematically under- or over-value quality when its assessment technology is biased or affected by rating-contingent regulation. With respect to the former, Katz et al. 2009 point to biased signals as the result of increased competition and the endeavor to increase profits. Accordingly, rating agencies relaxed rating criteria and avoided hiring new staff or investing in costly new databases and rating models prior to the financial crisis. With respect to rating-contingent regulation, the analysis by Opp et al. 2013 shows that the introduction of such regulation increases the volume of highly-rated securities.[185] This systematic misevaluation of bond quality is addressed in the following.

In this case, the signal reads $s(\theta_j) = \theta_j \pm \epsilon$, with $\epsilon > 0$ being a positive constant reflecting the misevaluation of bond quality.[186] Misevaluation implies that the bond quality perceived by lenders runs parallel to the 45°-line as exemplified in Figure 5.11. The figure depicts the case of a systematic overvaluation of quality, i.e. $s(\theta_j) = \max\left(\theta_j + \epsilon, \bar{\theta}\right)$.[187] Bonds j of quality $\theta_j \geq \bar{\theta} - \epsilon$ are signaled to be of the highest quality $\bar{\theta}$. Lenders' expectations are $\mathbb{E}[\theta_j|s(\theta_j)] = \max\left(\theta_j + \epsilon, \bar{\theta}\right)$, which gives the equilibrium price $\rho(\theta_j) = \max\left(\theta_j + \epsilon, \bar{\theta}\right)$. As borrowers still lack an alternative to selling their bond on the market, they accept any non-negative price and the set of marketing borrowers is again $\Theta(\rho) = \{\theta_j : 0 \leq \rho\}$. All lenders aside from the one buying the bond of quality $\bar{\theta}$ make losses, reflected by the shaded area in Figure 5.11. Specifically,

[182] In reality, credit ratings are not continuous as quality levels are clustered into rating notches. Here, a continuous distribution of θ and $s(\theta)$ is assumed for simplicity. However, the model could likewise be interpreted with discrete quality and signal.

[183] Rating agencies are private for-profit institutions and bond issuers pay them for ratings. There has been a diversified discussion concerning the conflicted interests of rating agencies in the light of the financial crisis, see e.g. Ackermann 2008, Acharya and Richardson 2009, Brunnermeier 2009, Stolper 2009 and White 2010.

[184] On ratings shopping, see Section 4.3.2.1. See also Sangiorgi and Spatt 2015, who find that selective disclosure of ratings lead to inefficient investment decisions. See also Grossman and Hart 1980 as well as Milgrom 1981 for the literature on the efficiency of the voluntary disclosure of available information.

[185] This finding is consistent with the view of e.g. Calomiris 2009, who argues that inaccurate ratings are desired by institutional investors as they do not fully internalize the negative effects on ultimate investors.

[186] Misevaluation prevails during the opening leg but is resolved thereafter. Moreover, ϵ is strictly positive but smaller than $\bar{\theta} - \underline{\theta}$.

[187] The maximum function is applied as no bond can be signaled a quality that is higher than $\bar{\theta}$, i.e. the maximum quality in the market. Lenders believe in the multiple signaling of $\bar{\theta}$ without knowing as each lender receives an individual signal and cannot observe the signal provided to other lenders.

each lender incurs a loss to the extent of ϵ up to bonds of quality $\theta_j > \bar{\theta} - \epsilon$ for which losses decrease towards 0 with θ_j increases. Compared to a situation without signal, borrowers are better off as R_B increases by the shaded area. Lenders' rent is given by[188]

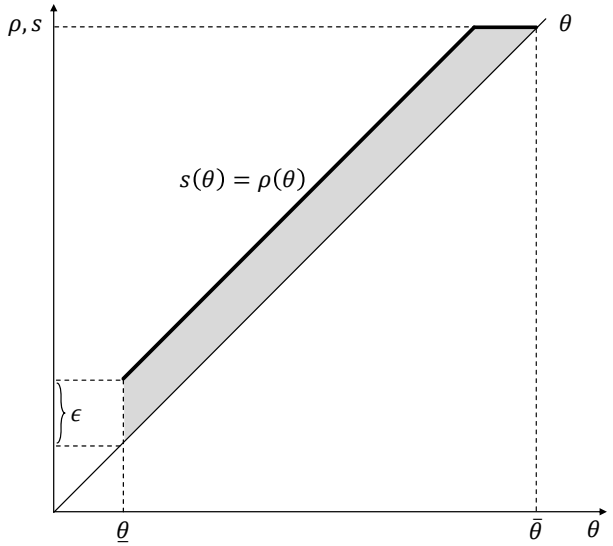
$$R_L = -(\bar{\theta} - \underline{\theta} - \frac{1}{2}\epsilon)\epsilon < 0, \tag{5.4}$$

while borrowers receive rent in the amount of[189]

$$R_B = \frac{\bar{\theta}^2 - \underline{\theta}^2}{2} - \Big(\underbrace{-(\bar{\theta} - \underline{\theta} - \frac{1}{2}\epsilon)\epsilon}_{R_L} \Big), \tag{5.5}$$

which is strictly positive for $R_L < 0$ as $\bar{\theta} > \underline{\theta}$. For $\epsilon = 0$, rents are equal to the benchmark as the case of symmetric information would be mimicked. This is intuitive as lenders and borrowers play a zero-sum game, which implies an aggregate surplus to the amount of $R = \frac{\bar{\theta}^2 - \underline{\theta}^2}{2}$, i.e. R remains unchanged. While asymmetric information leads to redistribution within the group of lenders and borrowers, a distorted signal involves a redistribution across groups. With a positively distorted signal, redistribution across groups is from lenders to borrowers. Preliminary findings are summarized in Lemma 5.1.

Figure 5.11: Equilibrium with positively distorted signal



Source: author's illustration.

Lemma 5.1 (Redistribution within and across groups through asymmetric information and distorted signal).

i) With asymmetric information, rent is redistributed within the groups of lenders and borrowers, namely from borrowers with high-quality bonds to those with low-quality bonds. Likewise, rent is redistributed from lenders purchasing bonds of low quality to those purchasing high-quality bonds.

[188] See the appendix for the derivation of Equation (5.4). R_L is negative as ϵ can at maximum be equal to $\bar{\theta} - \underline{\theta}$.
[189] See the appendix for the derivation of Equation (5.5).

ii) With asymmetric information and a positively distorted signal, rent is redistributed also across groups. Borrowers increase their rent at the expense of lenders.

5.3.1.5 Outside Option under Asymmetric Information

The signal is again neglected to facilitate the stepwise structure of the model. Instead, an outside option to selling bonds on the market is introduced, which is available to borrowers. The outside option could be provided by the central bank, with which borrowers can enter repos to receive liquidity (public repo). This liquidity can be used to make e.g. new loans, resulting in a positive return to borrowers. Despite the beneficial effect of collateralization in terms of mitigating counterparty risk, a private lender purchases a bond to realize a productive effect that arises from e.g. balance sheet effects or the benefit of using the specific bond (see Section 5.2). By contrast, the central bank does not benefit from receiving a specific bond as collateral but is supposed to exclusively mitigate counterparty risk. Hence, private repos are beneficial to both borrowers in terms of additional liquidity and lenders in terms of the productive use of the purchased bond, whereas the benefits of public repos are confined to borrowers.

The outside option gives borrowers a return of $\alpha(\theta_j)$. Like selling the bond on the market, making use of the outside option is costless. Borrowers sell bonds on the market whenever $\alpha(\theta_j) \leq \rho(\theta_j)$ and turn to the outside option otherwise, i.e. selling the bond on the market is preferred over the outside option in case of indifference. Accordingly, the set of marketing borrowers is characterized as $\Theta(\rho) = \{\theta_j : \alpha(\theta_j) \leq \rho(\theta_j)\}$. As long as $\rho \geq \alpha(\theta_j) \ \forall \ \theta_j$, all borrowers will dismiss the outside option and the outcome is equal to the one without outside option. However, with $\alpha(\bar{\theta}) > \mathbb{E}[\theta] = \rho$, at least the borrower owing the highest quality bond prefers the outside option over selling it on the market. Lenders would update their belief to $\mu = \mathbb{E}[\theta|\theta_j : \alpha(\theta_j) \leq \rho] < \mathbb{E}[\theta]$ in anticipation that the bond of highest quality will not be traded. Based on the updated belief, lenders offer a lower uniform bond price, which implies further borrowers with bonds of relatively high quality turning to the outside option. The phenomenon of adverse selection with different degrees of market unraveling depending on the outside option is examined in the following.

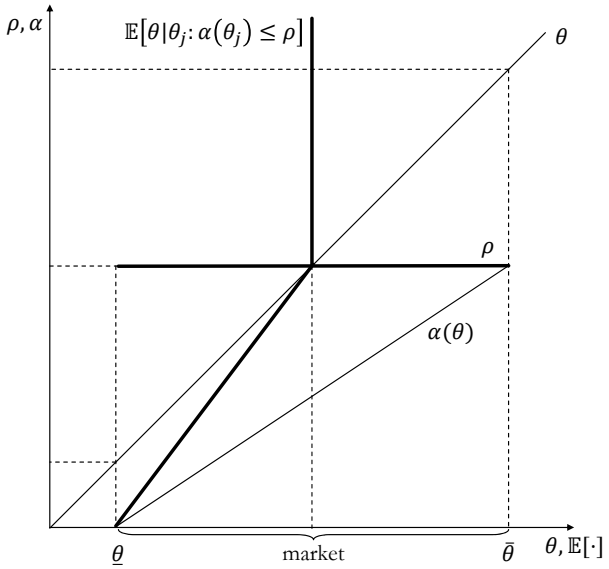
Outside Option and No Market Unraveling

Figure 5.12 depicts the situation in which the market with asymmetric information is not affected by the outside option as $\alpha(\bar{\theta}) = \mathbb{E}[\theta]$ and $\alpha(\theta) < \mathbb{E}[\theta] \ \forall \ \theta_j < \bar{\theta}$. Borrowers sell all bonds on the market at the uniform price $\rho = \mathbb{E}[\theta]$, with rents being equal to those under asymmetric information without outside option.

Outside Option and Partial Market Unraveling

Figure 5.13 illustrates the situation in which adverse selection leads to good-quality bonds being partially driven out of the market. Even if lenders expected all bonds to be sold on the market, some borrowers would turn to the outside option as this would give them more than the expected return in the market. Lenders update their belief and the equilibrium price ρ is characterized

Figure 5.12: Outside option and no market unraveling



Source: author's illustration.

by the intersection of the 45°-line and the line indicating expected bond quality. Borrowers for whom $\alpha(\theta_j) \leq \rho$ and hence $\theta_j \leq \theta_\alpha$ sell their bonds on the market. θ_α is the bond quality for which the owner is simply indifferent between selling the bond on the market and turning to the outside option. Taking into account that $\alpha(\theta) = \theta - \underline{\theta}$ as given in Figure 5.13, lenders realize zero rent while borrowers receive rent that equals aggregate surplus in the market and amounts to[190]

$$R_B = R = \frac{\bar{\theta}^2 - \underline{\theta}^2}{2} - \underline{\theta}(\bar{\theta} - \theta_\alpha). \tag{5.6}$$

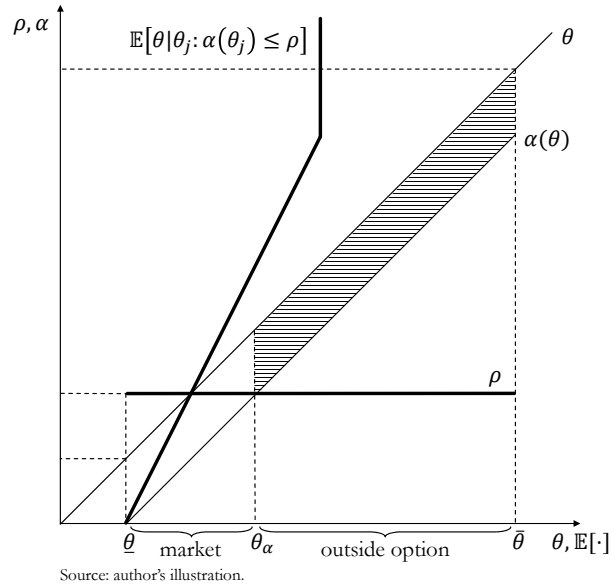
While aggregate surplus R was maximized and amounted to $\frac{\bar{\theta}^2 - \underline{\theta}^2}{2}$ in previous steps, it is lower now as $\alpha(\theta_j) < \theta_j \; \forall \; \theta_j$, i.e. the outside option yields less than the productive use of bonds by lenders. This is reflected in Equation (5.6) as $\bar{\theta} > \theta_\alpha$. Inefficiency owing to the less productive use of bonds with the outside option is given by the hatched area in Figure 5.13. Through the adverse selection, the market size decreases (i.e. it partially unravels) and the outside option does not fully compensate for the unexploited market potential.

Outside Option and Complete Market Unraveling

Complete market unraveling occurs for $\alpha(\underline{\theta}) = \underline{\theta}$ and $\alpha(\theta_j) < \theta_j \; \forall \; \theta_j > \underline{\theta}$, which is depicted in Figure 5.14. Progression of the outside option implies that $\rho = \underline{\theta}$ is the only price that would motivate a borrower to sell his bond on the market while being profitable for lenders. The borrower with the bond of quality $\underline{\theta}$ is simply indifferent between selling the bond on the market and turning to the outside option. If this borrower turns to the outside option, the market would completely unravel. In this case, the outcome would be inefficient as aggregate surplus decreases relative to the benchmark case. This inefficiency corresponds to the hatched area in Figure 5.14.

[190] See the appendix for the derivation of Equation (5.6).

Figure 5.13: Outside option and partial market unraveling



Source: author's illustration.

The preliminary results of the analysis with respect to information structure, the effect of a signal and consequences of the introduction of an outside option for borrowers are summarized in Proposition 5.1.

Proposition 5.1 (**Information structure, signal and outside option**).

i) With symmetric information, all bonds are traded at distinct prices that reflect bond quality and the equilibrium is efficient, i.e. aggregate surplus is maximized. With asymmetric information, the equilibrium remains efficient but all bonds are traded at a uniform price that reflects expected bond quality such that redistribution within the groups of lenders and borrowers takes place.

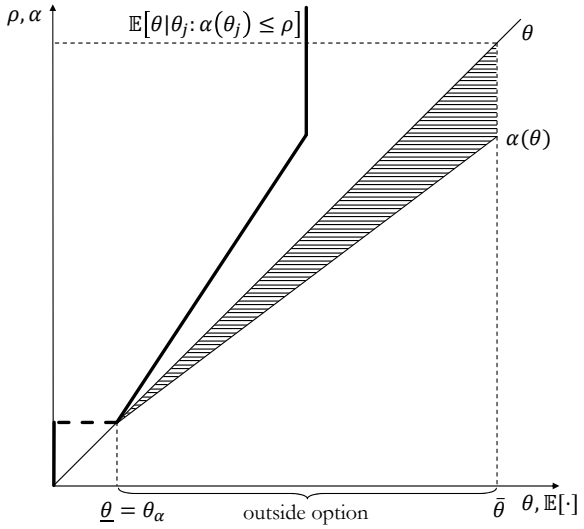
ii) An undistorted signal maintains efficiency and prevents redistribution among borrowers and lenders. If the signal was distorted, rents would be redistributed among and across borrowers and lenders as bonds are traded at distinct prices that reflect the distorted signal.

iii) Aggregate surplus decreases when borrowers are offered an outside option that is less productive than the use of bonds by lenders yet sufficiently high to drive better qualities out of the market.

5.3.2 The Eurosystem as Provider of Public Liquidity

The outside option is now modeled in a way that more strongly reflects its interpretation as the possibility to use bonds in public repos, i.e. in repos with the Eurosystem. Therefore, the outside option is modeled according to the Eurosystem's practice of clustering asset properties, which implies the pooling of public repo conditions.

Figure 5.14: Outside option and complete market unraveling



Source: author's illustration.

5.3.2.1 Pooling of Public Repo Conditions

Section 4.3.2.4 discussed how the Eurosystem clusters eligible assets in terms of liquidity, duration and credit quality. Furthermore, it was addressed that the application of supplementary haircuts leads to a divergence of nominal and effective haircuts. Section 4.4 introduced shortcomings associated with these two details of the Eurosystem risk control: first, the problem of insufficient hedge of collateral risk was raised; and second, the potential of adverse selection of collateral was addressed. Adverse selection may be the result of pooling public repo conditions, which is understood as the equalization of collateral values across assets of different intrinsic values. The market value of a bond equals the present value of future income flows related to that bond. For a given face value and interest rate, bonds of higher credit quality have a higher market value since their repayment is less uncertain. Consider e.g. two covered bank bonds of different credit quality and hence different market values: one is of high credit quality (AAA) with a market value of 100 and the other is of lower credit quality (A) with a market value of 50. When being pledged as collateral, the AAA-bond should be assigned a higher collateral value than the A-bond, e.g. 90 and 40. The pooling of repo conditions would imply that collateral values of the bonds are aligned, e.g. to 85 and 42.5. Perfectly-pooled repo conditions refer to a situation in which collateral values are uniform across bonds of different credit quality. This pooling of repo conditions is relevant for all eligible assets and particularly for own-use and non-marketable assets that are often subject to theoretical valuation.[191] This may reflect the result of the following three steps:

1. the application of simplified haircuts that are too large for high-quality collateral and too small for low-quality collateral;
2. the application of supplementary haircuts irrespective of credit quality;
3. the theoretical valuation of assets.

[191] Nyborg 2015 provides a precautionary assessment that about 77% by count or 17% by value of all eligible assets feature theoretical values. Moreover, the author documents that the fraction of theoretically valued assets is larger for lower-quality assets.

Application of Simplified Valuation Haircuts

Chapter 4 analyzed how the Eurosystem applies valuation haircuts to determine collateral values. Furthermore, the caveat was addressed that identical haircuts are applied within the same CQS to assets of different credit quality. In the following, private lenders are assumed to apply haircuts that fully reflect collateral risk. To distinguish the collateral value assigned by the Eurosystem from that assigned by private lenders, the former is labeled Φ_{CB} and the latter Φ_L. The application of simplified haircuts by the Eurosystem has two implications: on the one hand, collateral risk is not fully mitigated; and on the other, a fraction of assets is subsidized relative to the market.

To analyze the pooling of public repo conditions along one dimension of asset properties, bonds are considered as comparable in terms of coupon, duration and liquidity. For instance, Jumbo covered bank bonds with a fixed-rate coupon and residual maturity of two years are considered, which only differ in credit quality. Pooling public repo conditions through clustering asset properties is stylized in Figure 5.15 for fully-informed lenders. The figure illustrates the relation between bond quality θ (horizontal axis) and market value as well as collateral values in private and public repos (vertical axis). The range on the horizontal axis runs from $\hat{\theta}_3 \geq \underline{\theta}$ to $\hat{\theta}_1$ and reflects CQS 3,[192] such that $\hat{\theta}_3$ can be interpreted as the minimum credit rating threshold of the Eurosystem. Fully-informed lenders are willing to pay a price equal to the quality of the bond. Hence, lenders are assumed to apply haircuts h_L that are perfectly differentiated according to bond quality,[193] such that

$$\Phi_L(\theta_j) = \Big(1 - h_L(\theta_j)\Big)\Omega(\theta_j) = \rho(\theta_j) = \theta_j. \tag{5.7}$$

The market value is reflected by $\Omega(\theta)$ with the slope $\partial\Omega(\theta)/\partial\theta = 1$. Likewise, the slope of $\Phi_L(\theta)$ is[194]

$$\frac{\partial\Phi_L(\theta)}{\partial\theta} = \frac{\partial\Omega(\theta)}{\partial\theta} - \frac{\partial h_L}{\partial\theta}\Omega(\theta) - \frac{\partial\Omega(\theta)}{\partial\theta}h_L \equiv 1. \tag{5.8}$$

Let h_{CB} denote the haircut that the Eurosystem applies to (eligible) bond j of quality θ_j and market value $\Omega(\theta_j)$. The Eurosystem pools repo conditions by applying identical haircuts to bonds of different quality within CQS 1/2 and CQS 3. This implies that $h_{CB}(\theta_j) = h_{CB}\ \forall\ \theta_j \in [\hat{\theta}_3, \hat{\theta}_1)$ and the following collateral value assigned by the Eurosystem to bond j:

$$\Phi_{CB}(\theta_j) = (1 - h_{CB})\,\Omega(\theta_j). \tag{5.9}$$

[192] Note that the interpretation of θ as a broad argument of collateral quality (i.e. reflecting credit quality and liquidity) is narrowed to credit quality for technical convenience, i.e. liquidity is kept constant. CQS 1/2 summarizes eligible assets rated from "triple A" (corresponding to $\bar{\theta}$) to "single A" (corresponding to $\hat{\theta}_1$) while CQS 3 comprises all lower-rated assets down to the rating of "triple B" (corresponding to $\hat{\theta}_3$), cf. Figure 4.5. That is, CQS 1/2 is indexed by 1 and CQS 3 by 3 for the sake of simplicity. Repo conditions are pooled in both CQSs. In Figures 5.15 to 5.17, pooling is exemplified for CQS 3. However, replacing $\hat{\theta}_1$ with $\bar{\theta}$ and $\hat{\theta}_3$ with $\hat{\theta}_1$ would stylize pooling in CQS 1/2.

[193] Section 5.2.2 provided narrative evidence that lenders in the European repo market cluster collateral properties to a lesser degree than the Eurosystem. Moreover, bilateral repos can be assumed to imply no clustering as repo conditions are negotiated directly between counterparties for each repo.

[194] See Section 5.3.1.2. As $\partial\Omega(\theta)/\partial\theta = 1$, the condition for the identity to hold is $h_L = -(\partial h_L/\partial\theta)\Omega(\theta)$ with $\partial h_L/\partial\theta < 0$.

The slope of $\Phi_{CB}(\theta)$ is given by

$$\frac{\partial \Phi_{CB}(\theta)}{\partial \theta} = \frac{\partial \Omega(\theta)}{\partial \theta} - \frac{\partial h_{CB}}{\partial \theta}\Omega(\theta) - \frac{\partial \Omega(\theta)}{\partial \theta}h_{CB}. \tag{5.10}$$

Owing to the pooling of public repo conditions, the slope of $\Phi_{CB}(\theta)$ is smaller than that of $\Phi_L(\theta)$, i.e.

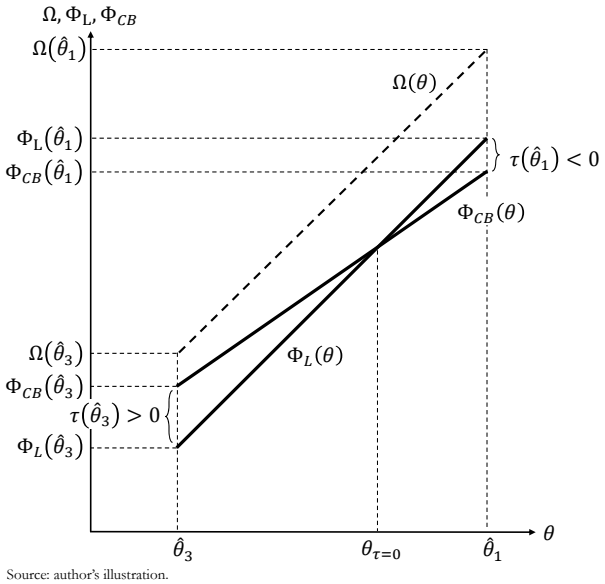
$$\frac{\partial \Phi_{CB}(\theta)}{\partial \theta} < 1 = \frac{\partial \Phi_L(\theta)}{\partial \theta}. \tag{5.11}$$

Therefore, $\Phi_{CB}(\theta)$ is larger than $\Phi_L(\theta)$ for bonds $\theta_j \in [\hat{\theta}_3, \theta_{\tau=0})$ but smaller otherwise. The bond of quality $\theta_{\tau=0}$ marks the threshold bond for which the Eurosystem assigns the same haircut and hence collateral value as private lenders.[195] The Eurosystem offers a subsidy to borrowers whenever repo conditions for a given bond are beneficiary in public repos compared to private repos. The value of this subsidy is given by

$$\Phi_{CB}(\theta_j) - \Phi_L(\theta_j) = \underbrace{\Big(h_L(\theta_j) - h_{CB}\Big)}_{\tau(\theta_j)}\Omega(\theta_j), \tag{5.12}$$

with $\tau(\theta_j)$ representing the haircut subsidy rate. For all $\theta_j \in [\hat{\theta}_3, \theta_{\tau=0})$, $\tau(\theta_j) > 0$ which implies that $h_{CB} < h_L(\theta_j)$. Analogously, $\tau(\theta_j) < 0$ for all $\theta_j \in (\theta_{\tau=0}, \hat{\theta}_1)$ and $h_{CB} > h_L(\theta_j)$.

Figure 5.15: Pooling of public repo conditions I: subsidization of collateral



Source: author's illustration.

The notion that private lenders are supposed to apply haircuts that reflect true collateral risk has two important implications. The interpretation of the subsidy is twofold: on the one hand, it can be a subsidy in the sense that the Eurosystem provides better conditions than private lenders in the repo market; and on the other, it can be a subsidy in the sense that the Eurosystem applies haircuts that do not reflect true collateral risk. As the market is assumed to impose such

[195] Note that by definition, $\theta_{\tau=0}$ corresponds to θ_α as θ_α is the bond quality for which the borrower was simply indifferent between the market and the outside option.

haircuts, the first important implication is that both interpretations apply analogously here. Second, adverse selection of collateral leads to increased risk exposure of the Eurosystem.[196] Collateral adversely selected to the Eurosystem increases its risk exposure as risk control is insufficient owing to overly-small haircuts. Lemma 5.2 summarizes the insights on the pooling of public repo conditions by the Eurosystem.

Lemma 5.2 (**Subsidization of collateral by the Eurosystem**). *Owing to the clustering of asset properties in the specification of public repo conditions, the Eurosystem subsidizes a fraction of eligible assets.*

i) A positive subsidy is provided to bonds of relatively low quality within each CQS as smaller haircuts are applied in public compared to private repos.

ii) A negative subsidy is imposed to bonds of relatively high quality within each CQS as larger haircuts are applied in public than in private repos.

iii) For only one bond, no subsidy is provided as the same haircut is applied in a public and a private repo.

Application of Supplementary Haircuts

Section 4.2.3.2 provided an overview of supplementary haircuts (i.e. add-on haircuts and valuation markdowns) that the Eurosystem applies to a broad range of collateral. With the exception of own-use covered bank bonds, supplementary haircuts are not differentiated with respect to credit quality. Hence, the same supplementary haircut is applied to assets within CQSs and even across CQSs. Taking supplementary haircuts into account, Φ_{CB} is expressed as[197]

$$\Phi_{CB}(\theta_j) = (1 - h^e_{CB})\Omega(\theta_j), \tag{5.13}$$

with

$$h^e_{CB} \equiv h_n + h_a + v - (h_n + h_a) \cdot v. \tag{5.14}$$

The last term reflects the interaction term, which biases the effective haircut downwards (see Section 4.3.2.3). This bias is larger for bonds of lower quality, i.e. for which larger haircuts are applied. As the same valuation markdown is applied to theoretically valued assets irrespective of credit quality, assets in CQS 3 are deducted by a relatively smaller effective haircut than those in CQS 1/2. This implies that repo conditions are aligned even across CQSs 1/2 and 3.

Within CQS 3, $h_n(\theta_j) = h_n \ \forall \ \theta_j \in [\hat{\theta}_3, \hat{\theta}_1)$ and hence $h^e_{CB}(\theta_j) = h^e_{CB} \ \forall \ \theta_j \in [\hat{\theta}_3, \hat{\theta}_1)$. The effective haircut applied to bonds in the same CQS is uniform but larger for any $h_a, v > 0$, i.e. $h^e_{CB} > h_n$. A larger effective haircut lowers the collateral value of a bond with higher market value more than the collateral value of a bond with lower market value. This effect is reflected in Figure 5.16, where Φ^e_{CB} indicates the collateral value that the Eurosystem determines based on

[196] Note that this is not necessarily the case. Risk exposure originates from the relation between the collateral value that the Eurosystem assigns to an asset and its true collateral value. Adverse selection relates to the collateral value assigned by the Eurosystem relative to the one assigned by private lenders. Here, private lenders are supposed to assign the true collateral value to a bond. Hence, adverse selection implies higher risk exposure.

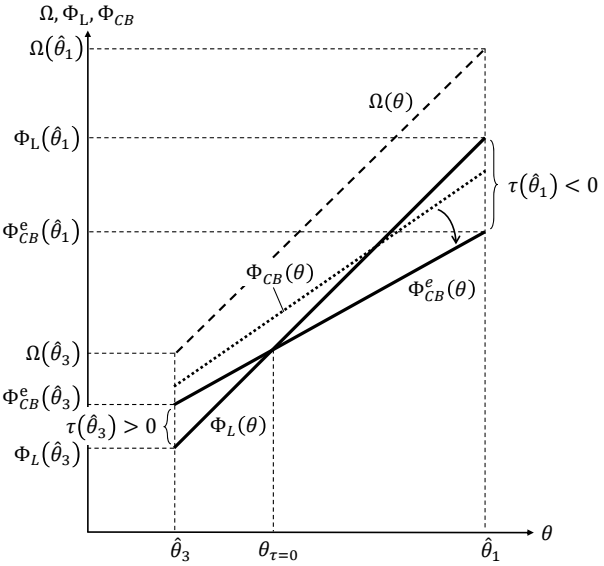
[197] Note that h^e_{CB} is the effective haircut that the central bank applies, h_n is the nominal haircut, h_a the add-on haircut and v the valuation markdown (cf. Section 4.3.2).

the application of the effective haircut (i.e. including supplementary haircuts). As $h^e_{CB} > h_n$, slopes of $\Phi_{CB}(\theta)$ and $\Phi^e_{CB}(\theta)$ differ, i.e.

$$\frac{\partial \Phi^e_{CB}(\theta)}{\partial \theta} < \frac{\partial \Phi_{CB}(\theta)}{\partial \theta} < 1 = \frac{\partial \Phi_L(\theta)}{\partial \theta} \; \forall \; h_a, v > 0. \tag{5.15}$$

The threshold quality $\theta_{\tau=0}$ is shifted to the left such that more bonds are negatively subsidized and less positively. Hence, the pooling of public repo conditions is fostered for assets to which supplementary haircuts are applied. Accordingly, conditions are not only aligned through uniform valuation haircuts applied to akin assets of different credit quality within the same CQS, but also through the application of supplementary haircuts, which implies a larger uniform effective haircut.

Figure 5.16: Pooling of public repo conditions II: application of supplementary haircuts



Source: author's illustration.

Theoretical Valuation of Assets

Section 3.1.4.2 addressed the Eurosystem's principles for collateral valuation, which hold crucial importance for determining collateral values.[198] For non-marketable assets, a theoretical value or simply the outstanding amount is considered. The value of marketable assets is calculated based on the market price. If the last available market price is older than (or has not moved for at least) five days, the Eurosystem assigns a theoretical value. Moreover, theoretical valuation is important for own-use assets, i.e. securities pledged by the issuing counterparty itself as no market price exists. Nyborg 2015 documents that about 77% by count or 17% by value of all eligible assets feature theoretical values. It is addressed in the following that theoretical valuation may foster pooling public repo conditions as it could give rise to valuation errors.

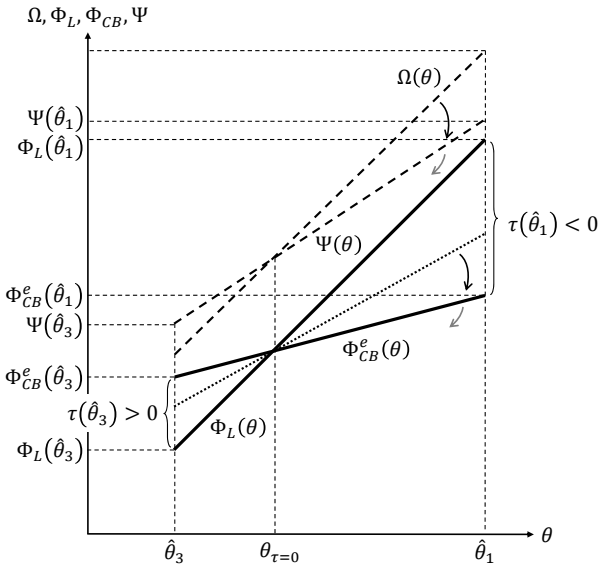
[198] Therefore, valuation of collateral could be interpreted as the de facto seventh property of credit terms (Section 2.3).

In case of valuation errors, the theoretical value $\Psi(\theta_j)$ that the Eurosystem assigns to bond j is given by

$$\Psi(\theta_j) = \Big(1 + \varphi(\theta_j)\Big)\Omega(\theta_j), \tag{5.16}$$

with $\varphi(\theta_j)$ being the valuation error.[199] The case of valuation errors is stylized in Figure 5.17 under the assumption that all bonds are theoretically valued. All bonds $\theta_j \in [\hat{\theta}_3, \theta_{\tau=0})$ are overvalued and their theoretical value corresponds to $\Psi(\theta_j) = (1 + \varphi(\theta_j))\Omega(\theta_j) > \Omega(\theta_j)$ as $\varphi(\theta_j) > 0$. By contrast, all bonds $\theta_j \in (\theta_{\tau=0}, \hat{\theta}_1)$ are undervalued such that $\Psi(\theta_j) = (1 + \varphi(\theta_j))\Omega(\theta_j) < \Omega(\theta_j)$ with $\varphi(\theta_j) < 0$. Only the valuation of bond $\theta_{\tau=0}$ is unbiased, i.e. $\Psi(\theta_{\tau=0}) = \Omega(\theta_{\tau=0})$ as $\varphi(\theta_{\tau=0}) = 0$. Incorrect valuations may be ascribed to the Eurosystem avoiding disperse theoretical valuation of bonds such that it tends to assign modest theoretical values ("central tendency error", see e.g. GUILFORD 1954 as well as ROSENTHAL and ROSNOW 1991). Moreover, a general misperception of bond quality could prevail.

Figure 5.17: Pooling of public repo conditions III: valuation errors



Source: author's illustration.

Valuation errors as described above imply a clockwise rotation of $\Psi(\theta)$ away from a fair theoretical value, which implies a further flattening of $\Phi_{CB}(\theta)$. The larger the misvaluation, the flatter is $\Phi_{CB}(\theta)$. For all bonds $\theta_j \in [\hat{\theta}_3, \theta_{\tau=0})$, the subsidy $\tau(\theta_j)$ increases, while for all other bonds $\theta_j \in (\theta_{\tau=0}, \hat{\theta}_1)$, it becomes more negative. In the most extreme case, this could lead to the slope of $\Phi_{CB}(\theta)$ equal to zero and public repo conditions that are perfectly aligned within CQSs, i.e. $\Phi^e_{CB}(\theta_j) = \Phi^e_{CB}(\theta_{\tau=0}) \; \forall \; \theta_j \in [\hat{\theta}_3, \hat{\theta}_1)$ and $\partial\Phi^e_{CB}(\theta)/\partial\theta = 0$.

In conclusion, public repo conditions are pooled within CQSs by clustering asset properties in three steps: *(i)* the application of simplified haircuts that are too large for high-quality bonds and too small for low-quality bonds; *(ii)* the application of supplementary haircuts irrespective of credit quality; and *(iii)* the theoretical valuation of bonds when they lack a market value. However, $\Phi_{CB}(\theta)$ would become perfectly flat ($\partial\Phi_{CB}(\theta)/\partial\theta = 0$) only for a uniform theoretical valuation of all bonds within the same CQS. Perfectly-pooled repo conditions within CQSs are

[199] $\varphi(\theta_j)$ is characterized as follows: $\partial\varphi(\theta)/\partial\theta < 0$; $\partial^2\varphi(\theta)/\partial\theta^2 > 0$; $0 < \varphi(0) < 1$; $\varphi(\theta_{\tau=0}) = 0$; $\varphi(\theta_j) > 0 \; \forall \; \theta_j \in [0, \theta_{\tau=0})$; $\varphi(\theta_j) < 0 \; \forall \; (\theta_{\tau=0}, \infty)$.

assumed as a simplification in the following extension of the basic model to elaborate on the implications of the design of the outside option as offered by the Eurosystem. All implications would qualitatively hold if repo conditions were not perfectly pooled within CQSs, i.e. $0 < \partial\Phi_{CB}(\theta)/\partial\theta < 1 = \partial\Phi_L(\theta)/\partial\theta$.

5.3.2.2 Extended Model With Pooled Public Repo Conditions and *Correct* Ratings

The basic model with asymmetric information and correct ratings is extended by introducing pooled public repo conditions as derived in the previous section. The stylized case of perfectly-pooled public repo conditions within CQSs is modeled hereafter such that

$$\begin{aligned}\alpha(\theta_j) &= \Phi^e_{CB}(\theta_j) = \Big(1 - h^e(\theta_j)\Big)\Psi(\theta_j) \\ &= \Phi^e_{CB}(\theta_{\alpha_k}) = \Big(1 - h^e(\theta_{\alpha_k})\Big)\Psi(\theta_{\alpha_k}) = \alpha(\theta_{\alpha_k}) \;\forall\; \theta_j, \theta_{\alpha_k},\end{aligned} \tag{5.17}$$

with $k \in \{1, 3\}$ indicating the CQS and θ_{α_k} the bond against which public repo conditions are perfectly pooled.[200] Bond quality is supposed to be unknown to lenders but signaled correctly by the rating agency such that $s(\theta_j) = \theta_j \;\forall\; \theta_j$. The Eurosystem defines CQSs according to credit ratings such that bonds rated between $\hat{s}_1$ and $\bar{s}$ are arranged in CQS 1/2 and those rated between $\hat{s}_3$ and $\hat{s}_1$ are summarized in CQS 3. Moreover, the Eurosystem ties down for each CQS k a rating s_{α_k}, implicitly determining the bond for which the owner is indifferent between entering a private or a public repo. Public repo conditions for bonds rated within the same CQS k are pooled and aligned to the private repo condition of this bond rated s_{α_k} that are given by $\Phi_L(\theta_{\alpha_k}) = \rho(\theta_{\alpha_k}) = s(\theta_{\alpha_k}) = \theta_{\alpha_k}$. Hence, public repo conditions are determined by the Eurosystem such that $\Phi^e_{CB}(\theta_{\alpha_k}) = \alpha(\theta_{\alpha_k}) = \theta_{\alpha_k}$.

In CQS 1/2, $\alpha(\theta_{\alpha_1})$ is further specified as $\alpha(\theta_{\alpha_1}) \equiv \frac{\rho(\bar{s})+\rho(\hat{s}_1)}{b_1}$ with b_1 implicitly defining the fraction of bonds that is subsidized relative to private repos. b_1 is restricted by $[\underline{b}_1 \equiv \frac{\rho(\bar{s})+\rho(\hat{s}_1)}{\rho(\bar{s})}, \bar{b}_1 \equiv \frac{\rho(\bar{s})+\rho(\hat{s}_1)}{\rho(\hat{s}_1)}]$ with $\underline{b}_1$ being the lower and $\bar{b}_1$ the upper bound of b_1. For CQS 3, it holds analogously that $\alpha(\theta_{\alpha_3}) \equiv \frac{\rho(\hat{s}_1)+\rho(\hat{s}_3)}{b_3}$ with $b_3 \in [\underline{b}_3 \equiv \frac{\rho(\hat{s}_1)+\rho(\hat{s}_3)}{\rho(\hat{s}_1)}, \bar{b}_3 \equiv \frac{\rho(\hat{s}_1)+\rho(\hat{s}_3)}{\rho(\hat{s}_3)}]$. Hence, the Eurosystem can implicitly determine the fraction of bonds rated within each CQS k that it subsidizes relative to private repos through the choice of b_k.[201] The higher b_k, the lower the fraction of bonds in CQS k that are subsidized relative to private repos. As $s(\theta_j) = \theta_j \;\forall\; \theta_j$, public repo conditions are given by

$$\alpha(\theta_j) = \begin{cases} 0 & \forall\; \theta_j : s(\theta_j) \in [\underline{s}, \hat{s}_3); \\ \frac{\hat{\theta}_1+\hat{\theta}_3}{b_3} & \forall\; \theta_j : s(\theta_j) \in [\hat{s}_3, \hat{s}_1); \\ \frac{\bar{\theta}+\hat{\theta}_1}{b_1} & \forall\; \theta_j : s(\theta_j) \in [\hat{s}_1, \bar{s}]. \end{cases} \tag{5.18}$$

Bonds rated below the minimum rating threshold $\hat{s}_3$ are ineligible in public repos such that the outside option of borrowers owning these bonds is to leave bonds unexploited and receive nothing. Bonds rated at or above $\hat{s}_3$ are eligible in public repos. Public repo conditions are

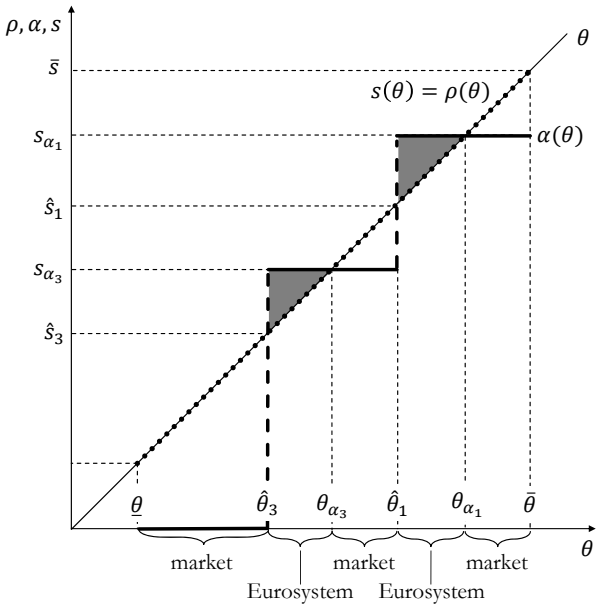
[200] Note again that for the sake of clarity, CQS 1/2 is indexed by 1 (and CQS 3 by 3).

[201] Note that $b_k > 1$. For $b_k = 2$, the bond rated θ_{α_k} would correspond to the median-rated bond in CQS k such that half of bonds are subsidized and the other half are discriminated relative to private repos.

pooled for bonds of different quality rated within the same CQS k and aligned to the conditions that private lenders would stipulate for the bond of quality θ_{α_k}. Hence, the value of the outside option for bonds rated within CQS 1/2 is $\alpha(\theta_j) = \frac{\bar{\theta}+\hat{\theta}_1}{b_1}$ $\forall$ $\theta_j : s(\theta_j) \in [\hat{s}_1, \bar{s}]$ and $\alpha(\theta_j) = \frac{\hat{\theta}_1+\hat{\theta}_3}{b_3}$ $\forall$ $\theta_j : s(\theta_j) \in [\hat{s}_3, \hat{s}_1)$ for bonds rated within CQS 3.

The situation is stylized in Figure 5.18 with correct ratings being reflected by the dotted line. Borrowers who own a bond of quality $\theta_j < \hat{\theta}_3$ sell this bond on the market at the price $\rho(\theta_j) = s(\theta_j) = \theta_j$. The same holds for borrowers owning a bond of relatively high-quality in each CQS, i.e. bonds of quality $\theta_j \in [\theta_{\alpha_3}, \hat{\theta}_1) \cap [\theta_{\alpha_1}, \bar{\theta}]$, as the borrowers receive at least as much in the market as in a public repo, i.e. $\rho(\theta_j) \geq \alpha(\theta_j)$ $\forall$ $\theta_j \in [\theta_{\alpha_3}, \hat{\theta}_1) \cap [\theta_{\alpha_1}, \bar{\theta}]$. However, bonds of relatively low quality in each CQS, i.e. bonds of quality $[\hat{\theta}_3, \theta_{\alpha_3}) \cap [\hat{\theta}_1, \theta_{\alpha_1})$ are pledged in public repos with the Eurosystem because the outside option gives the borrowers more liquidity, i.e. $\alpha(\theta_j) > \rho(\theta_j)$ $\forall$ $\theta_j \in [\hat{\theta}_3, \theta_{\alpha_3}) \cap [\hat{\theta}_1, \theta_{\alpha_1})$.

Figure 5.18: Perfectly-pooled public repo conditions (within CQSs) and correct ratings



Source: author's illustration.

While private lenders are again left with zero rent ($R_L = 0$), the rent of borrowers corresponds to the aggregate surplus ($R_B = R$) and is given by[202]

$$R_B = \frac{\bar{\theta}^2 - \underline{\theta}^2}{2} + \underbrace{\frac{\hat{\theta}_1^2 + \hat{\theta}_3^2}{2} + \frac{1}{2}\left(\frac{\hat{\theta}_1 + \hat{\theta}_3}{b_3}\right)^2 + \frac{1}{2}\left(\frac{\bar{\theta} + \hat{\theta}_1}{b_1}\right)^2 - \frac{\hat{\theta}_3(\hat{\theta}_1 + \hat{\theta}_3)}{b_3} - \frac{\hat{\theta}_1(\bar{\theta} + \hat{\theta}_1)}{b_1}}_{\text{additional rent from pooled public repo conditions}}. \quad (5.19)$$

R_B is maximized for b_k equal to the lower bound, i.e. $b_1 = \frac{\rho(\bar{s})+\rho(\hat{s}_1)}{\rho(\bar{s})}$ as well as $b_3 = \frac{\rho(\hat{s}_1)+\rho(\hat{s}_3)}{\rho(\hat{s}_1)}$, and is minimized for b_k equal to the upper bound, i.e. $b_1 = \frac{\rho(\bar{s})+\rho(\hat{s}_1)}{\rho(\hat{s}_1)}$ and $b_3 = \frac{\rho(\hat{s}_1)+\rho(\hat{s}_3)}{\rho(\hat{s}_3)}$. In the former case, all eligible bonds (except for the bond for which the owner is indifferent) are pledged with the Eurosystem and only ineligible bonds, i.e. $\theta_j \in [\underline{\theta}, \hat{\theta}_3)$, are sold on the market. In the latter case, no borrower turns to the Eurosystem and all bonds are sold on the market.

[202] See the appendix for the derivation of Equation (5.19).

In this case, the benchmark outcome (symmetric information) is mimicked as borrowers receive rent to the amount of $R_B = \frac{\bar{\theta}^2 - \underline{\theta}^2}{2}$.

For any b_k smaller than the upper bound, the Eurosystem provides additional rent to borrowers, as reflected in Equation (5.19) and indicated by the shaded areas in Figure 5.18. This provision is at the risk of the Eurosystem as it turns into a loss of the Eurosystem if the borrower fails to repurchase the bond in the closing leg. Hence, the Eurosystem bears risk that is equal to the additional rent provided to borrowers and corresponds to

$$R_{CB} = -\left(\frac{\hat{\theta}_1^2 + \hat{\theta}_3^2}{2} + \frac{1}{2}\left(\frac{\hat{\theta}_1 + \hat{\theta}_3}{b_3} \right)^2 + \frac{1}{2}\left(\frac{\bar{\theta} + \hat{\theta}_1}{b_1} \right)^2 - \frac{\hat{\theta}_3(\hat{\theta}_1 + \hat{\theta}_3)}{b_3} - \frac{\hat{\theta}_1(\bar{\theta} + \hat{\theta}_1)}{b_1} \right). \tag{5.20}$$

The Eurosystem pays prices $\alpha(\theta_{\alpha_k})$ and receives bonds that have to be liquidated in case of borrower default. Liquidation would give the Eurosystem θ_j for each bond j such that it would be left with a loss to the amount of $\alpha(\theta_{\alpha_k}) - \theta_j$ for each bond j. R_{CB} positively depends on b_k since an increase in b_k implies fewer bonds being subsidized by the Eurosystem and more borrowers turning to the market.

This represents a rationale for GLOC according to which there is adverse selection of collateral. The Eurosystem receives relatively low-quality bonds within each CQS, while bonds of relatively high quality are sold on the market. The reason for this finding is the subsidization of relatively low-quality bonds in each CQS through the pooling of repo conditions. Upon first glance, aggregate surplus in the market is increased beyond the benchmark case with symmetric information. Some borrowers enjoy such good conditions in public repos that they can realize a higher return than they would when selling the bonds on the market. The rent of lenders remains zero. Upon further consideration, additional rent for borrowers is at the cost of the Eurosystem, which bears risk in terms of a potential loss (illustrated by the shaded areas in Figure 5.18). In case of borrower default, bonds would have to be liquidated rather than being repurchased in the closing leg. The Eurosystem could then realize a liquidation value smaller than the liquidity provided in the opening leg. In case of this adverse outcome, the additional rent of borrowers in the opening leg is matched by a loss of the Eurosystem thereafter. This finding is summarized in the following proposition.

Proposition 5.2 (**Pledge of low-quality bonds in public repos**). *By offering a uniform outside option to bonds within each CQS, the Eurosystem attracts low-quality bonds within each CQS.*

i) While bonds of relatively high quality within each CQS are sold on the market,

ii) bonds of relatively low quality within each CQS are used in public repos with the Eurosystem.

iii) Rent of borrowers owning bonds of relatively low quality within each CQS is increased at the risk of the Eurosystem.

The finding shows that borrowers turn to the central bank despite information on bond quality being de facto symmetric. Essentially, a borrower is assumed to seek the most profitable yet feasible utilization for his bond. Whenever the conditions offered by the central bank are better

than in the repo market and the bond is eligible for a public repo, the borrower will turn to the central bank. Therefore, pooling of public repo conditions is one explanation for the observation that collateral was increasingly pledged with the Eurosystem rather than being sold on the market. Another possible explanation is that it is not feasible for borrowers to sell their bond on the market. Stiglitz and Weiss 1981 describe such a constraint as a credit rationing of the supply side. Contrasting the view that the underprovision of credit represents a temporary disequilibrium through an exogenous shock, a loan market may in equilibrium be characterized by credit rationing. Similarly, in the present model, the possibility to sell bonds on the market could be limited and borrowers would have to turn to the outside option. However, with pooling of public repo conditions, the Eurosystem would still underbid the market and provide better conditions than private lenders for at least a fraction of bonds.

5.3.2.3 Extended Model with Pooled Public Repo Conditions and *Distorted* Ratings

In the last step of the analysis, ratings of bond quality are no longer assumed to be correct but rather positively proportionally distorted in the opening leg.[203] This corresponds to the case in which the quality assessment technology of the rating agency is systematically biased owing e.g. to overly optimistic market sentiment.

With positive proportional distortion, bonds are rated $s(\theta_j) = \max[(\theta_j + \epsilon), \bar{\theta}]$ with $\epsilon > 0$. Distorted ratings result in a bias of $\Omega(\theta_j)$ and of $\Phi_L(\theta_j)$ such that $\Phi_L(\theta_j) = \rho(\theta_j) = s(\theta_j) = \max[(\theta_j + \epsilon), \bar{\theta}]$. Distorted ratings are depicted by the dotted line in Figure 5.19. As the Eurosystem defines rating thresholds for eligibility and between CQSs in terms of minimum ratings, i.e. $\hat{s}_k$ for $k \in \{1, 3\}$, bond quality levels that are incorporated into CQSs de facto range from $\hat{\theta}_1 - \epsilon$ to $\bar{\theta}$ in CQS 1/2 and from $\hat{\theta}_3 - \epsilon$ to $\hat{\theta}_1 - \epsilon$ in CQS 3 as $s(\hat{\theta}_1 - \epsilon) = \hat{s}_1$ and $s(\hat{\theta}_3 - \epsilon) = \hat{s}_3$.

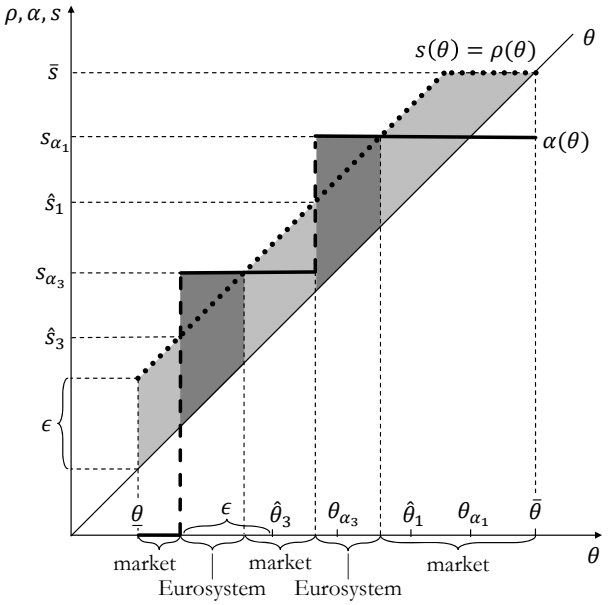
The borrower who is simply indifferent between entering a private and a public repo is no longer the owner of the bond of quality θ_{α_k} because bond quality implying indifference decreases due to the distortion to $\theta_{\alpha_k} - \epsilon$. This implies that the value of the outside option in CQS k is endogenous to the Eurosystem and decreases by ϵ. While the number of subsidized bonds is unaffected (as $\theta_{\alpha_k} - \epsilon - \hat{\theta}_k + \epsilon = \theta_{\alpha_k} - \hat{\theta}_k$), subsidized bonds are of lower quality. Bonds of quality higher than $\hat{\theta}_3 - \epsilon$ are signaled to be of quality $\theta_j \geq \hat{s}_3$ and are eligible in a public repo at pooled conditions $\alpha(\theta_{\alpha_1}) = \alpha(\theta_j)\ \forall\ \theta_j \in [\hat{\theta}_1 - \epsilon, \bar{\theta}]$, i.e. within CQS 1/2, and $\alpha(\theta_{\alpha_3}) = \alpha(\theta_j)\ \forall\ \theta_j \in [\hat{\theta}_3 - \epsilon, \hat{\theta}_1 - \epsilon)$ within CQS 3.

Figure 5.19 illustrates that bonds of quality $\theta_j \in [\hat{\theta}_3 - \epsilon, \theta_{\alpha_3} - \epsilon) \cup [\hat{\theta}_1 - \epsilon, \theta_{\alpha_1} - \epsilon)$ are pledged in public repos with the Eurosystem rather than being sold on the market. CQS 3 is effectively shifted to bonds of lower quality, while CQS 1/2 is extended to the extent of the distortion. As shown in Section 5.3.1.4, the positive distortion of ratings implies higher rents for borrowers at the expense of lenders who believe in the signal and are willing to pay prices that are too high

[203] See Eberl and Weber 2013 for the case of negatively proportionally distorted ratings. In this case, the subsidized bonds are of higher quality. The Eurosystem bears less risk as it receives bonds of higher quality. If the Eurosystem believes in market prices that are too low relative to true bond quality owing to overly prudent ratings, it can reduce the price distortion and offer a price that better reflects the true quality. However, this implies a loss in aggregate surplus as borrowers turn to the Eurosystem, which brings them more than in the market (owing to the negatively distorted signal) but on aggregate gives less than the productive use of bonds by private lenders.

for the given bond quality. For lenders receiving bonds of quality $\theta_j > \bar{\theta} - \epsilon$, the adverse effect of distorted ratings decreases towards zero with increasing bond quality.

Figure 5.19: Perfectly-pooled outside option (within CQSs) and positively distorted ratings



Source: author's illustration.

Lenders realize rent to the amount of[204]

$$R_L = -\left(\bar{\theta} - \underline{\theta} - \frac{1}{2}\epsilon + \hat{\theta}_1 + \hat{\theta}_3 - \frac{\hat{\theta}_1 + \hat{\theta}_3}{b_3} - \frac{\bar{\theta} + \hat{\theta}_1}{b_1}\right)\epsilon, \tag{5.21}$$

which negatively depends on b_k and vanishes for $\epsilon = 0$. Moreover, Equation (5.21) resembles Equation (5.4) for b_k set at the upper bound, while R_L is smaller for any smaller b_k as more collateral is pledged in public repos. By contrast, borrowers receive rent that is given by[205]

$$R_B = \frac{\bar{\theta}^2 - \underline{\theta}^2}{2} + \underbrace{\frac{\hat{\theta}_1^2 + \hat{\theta}_3^2}{2} + \frac{1}{2}\left(\frac{\hat{\theta}_1 + \hat{\theta}_3}{b_3}\right)^2 + \frac{1}{2}\left(\frac{\bar{\theta} + \hat{\theta}_1}{b_1}\right)^2 - \frac{\hat{\theta}_3(\hat{\theta}_1 + \hat{\theta}_3)}{b_3} - \frac{\hat{\theta}_1(\bar{\theta} + \hat{\theta}_1)}{b_1}}_{\text{add. rent from pooled public repo conditions}} + \underbrace{\left(\bar{\theta} - \underline{\theta} - \frac{1}{2}\epsilon\right)\epsilon}_{\text{add. rent from rating distortion}}, \tag{5.22}$$

which is convexly decreasing in b_k. For $\epsilon = 0$, Equation (5.22) resembles Equation (5.19) as the case of correct ratings would be mimicked. Plugging in the upper bound of b_k, i.e. $\bar{b}_1 = \frac{\bar{\theta}+\hat{\theta}_1}{\hat{\theta}_1}$ and $\bar{b}_3 = \frac{\hat{\theta}_1+\hat{\theta}_3}{\hat{\theta}_3}$, gives $R_B = \frac{\bar{\theta}^2-\underline{\theta}^2}{2} + \left(\bar{\theta} + \underline{\theta} - \frac{1}{2}\epsilon\right)\epsilon$, which mimics R_B under asymmetric information and a positively distorted signal but without an outside option as all bonds are sold on the market. Likewise, $R_L = -(\bar{\theta} - \underline{\theta} - \frac{1}{2}\epsilon)\epsilon$, i.e. R_L under asymmetric information and positively distorted signal but without outside option. An increase in the value of the outside option from lowering b_k down to $\underline{b}_1 = \frac{\bar{\theta}+\hat{\theta}_1}{\bar{\theta}}$ and $\underline{b}_3 = \frac{\hat{\theta}_1+\hat{\theta}_3}{\hat{\theta}_1}$ makes R_L less negative toward

[204] See the appendix for the derivation of Equation (5.21).
[205] See the appendix for the derivation of Equation (5.22).

$R_L = -(\hat{\theta}_3 - \underline{\theta} - \frac{1}{2}\epsilon)\epsilon$, while R_B increases convexly. Aggregate surplus in the market corresponds to

$$R = \frac{\bar{\theta}^2 - \underline{\theta}^2}{2} + \frac{\hat{\theta}_1^2 + \hat{\theta}_3^2}{2} + \frac{1}{2}\left(\frac{\hat{\theta}_1 + \hat{\theta}_3}{b_3}\right)^2 + \frac{1}{2}\left(\frac{\bar{\theta} + \hat{\theta}_1}{b_1}\right)^2 - \frac{\hat{\theta}_3(\hat{\theta}_1 + \hat{\theta}_3)}{b_3} - \frac{\hat{\theta}_1(\bar{\theta} + \hat{\theta}_1)}{b_1} + \left(\frac{\hat{\theta}_1 + \hat{\theta}_3}{b_3} + \frac{\bar{\theta} + \hat{\theta}_1}{b_1} - \hat{\theta}_3 - \hat{\theta}_1\right)\epsilon, \tag{5.23}$$

which differs from aggregate surplus with correct ratings by the last term, i.e. for $\epsilon > 0$.

Risk to the Eurosystem is illustrated by the dark-shaded areas in Figure 5.19 and given by[206]

$$R_{CB} = -\left(\frac{\hat{\theta}_1^2 + \hat{\theta}_3^2}{2} + \frac{1}{2}\left(\frac{\hat{\theta}_1 + \hat{\theta}_3}{b_3}\right)^2 + \frac{1}{2}\left(\frac{\bar{\theta} + \hat{\theta}_1}{b_1}\right)^2 - \frac{\hat{\theta}_3(\hat{\theta}_1 + \hat{\theta}_3)}{b_3} - \frac{\hat{\theta}_1(\bar{\theta} + \hat{\theta}_1}{b_1}\right) - \epsilon\left(\frac{\hat{\theta}_1 + \hat{\theta}_3}{b_3} + \frac{\bar{\theta} + \hat{\theta}_1}{b_1} - \hat{\theta}_3 - \hat{\theta}_1\right), \tag{5.24}$$

which again positively depends on b_k and mimics risk to the Eurosystem in case of correct ratings, i.e. Equation (5.20), for $\epsilon = 0$. As the value of the outside option for eligible bonds is implicitly determined by private repo conditions, it is upward-distorted, just like prices on the market. In addition, the Eurosystem deems eligible bonds of quality lower than its initial quality threshold $\hat{\theta}_3$ to the extent of $\hat{\theta}_3 - \epsilon$. Therefore, the quality of bonds pledged with the Eurosystem is lower as CQS 3 is effectively shifted to bonds of lower quality and CQS 1/2 is extended to the extent of the rating distortion. The coincidence of pooling of public repo conditions and upward distortion of credit ratings amplifies risk to the Eurosystem. For each bond pledged with the Eurosystem, the risk corresponds to the distance between the price the Eurosystem pays $\alpha(\theta_j)$ and true quality θ_j as in case of counterparty default the Eurosystem has to liquidate the bond. The Eurosystem generates additional rent for borrowers exceeding the additional rent that private lenders already provide owing to distorted ratings (light-shaded area). The findings of this last step of analysis are summarized in Proposition 5.3.

Proposition 5.3 (**Intensified pledge of low-quality bonds in public repos owing to positively distorted ratings**). *With the systematic overvaluation of bond quality owing to a positively distorted signal, the Eurosystem's attraction of low-quality bonds is intensified. Both CQSs are expanded beyond the control of the Eurosystem to the extent of the rating distortion.*

1. *While bonds of relatively high quality in each CQS are sold on the market, eligible bonds of relatively low quality in each CQS are used in public repos with the Eurosystem. The quality of bonds attracted by the Eurosystem is lower than in the case without rating distortion.*
2. *Additional rent for borrowers comes at the risk of private lenders owing to the distorted signal. For borrowers owning bonds of relatively low quality within each CQS, the rent is even further increased at the risk of the Eurosystem.*

[206] See the appendix for the derivation of Equation (5.24).

5.4 Credit Quality of Collateral Pledged with the Eurosystem Revisited

The model elaborated on the adverse selection of collateral, finding that the central bank would attract assets of relatively low quality if it pooled repo conditions for collateral of different quality. This attraction of low-quality assets is intensified for positively distorted ratings as collateral eligibility is extended and beyond the control of the Eurosystem. Thus, pooling of public repo conditions is a potential means of the central bank to expand liquidity provision to mitigate crisis. However, crisis mitigation comes along with cost of adverse *qualitative* effects that imply increase in collateral risk. Collateral risk was already addressed in Section 5.1 when the credit quality of pledged assets was investigated (right panel of Figure 5.3). However, this investigation was superficial as credit quality was considered in terms of CQSs, which comprise up to seven credit rating notches. No insight was provided into the distribution of collateral quality within CQSs, i.e. across credit rating notches. The following revisits the distribution of collateral and refines the right panel of Figure 5.3 to the distribution of collateral across credit rating notches. Four stylized cases are considered: *(i)* uniform distribution across rating notches, *(ii)* distribution reflecting the one of eligible marketable assets on 6 March 2015, *(iii)* distribution taking into account linear adverse selection of collateral and *(iv)* distribution allowing for progressive adverse selection.[207]

Initially, it is supposed that the distribution of collateral is uniform across rating notches. The development of collateral credit quality for this scenario is depicted in the left panel of Figure 5.20. However, Figure 4.6 exemplified the distribution of eligible marketable assets for one specific day, which was not uniform across rating notches. The right panel of Figure 5.20 projects this anecdotal evidence of the distribution of eligible marketable assets on pledged collateral. Compared to the previous scenario, the fraction of "AAA" and "AA"-rated collateral increases. Moreover, it is supposed that more assets with relatively low rating such as "A" and "BBB+" were pledged.

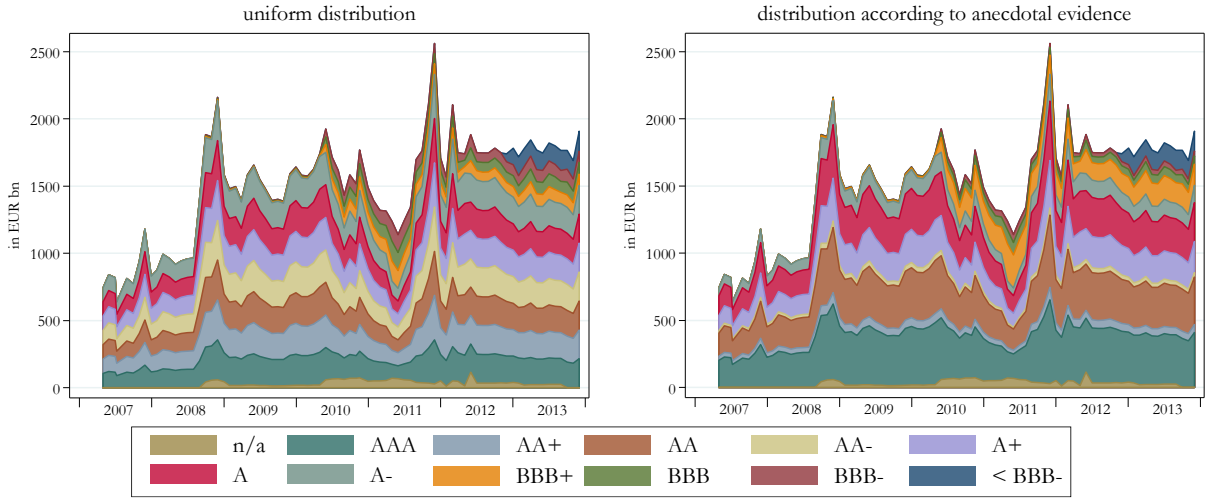
However, these scenarios neglect the implications of GLOC derived within the model of the previous section. According to GLOC, collateral of relatively low quality in each CQS is pledged with the central bank. This implies that in CQS 1/2, assets rated "A-" are more likely pledged than assets rated "A", which in turn are more likely pledged than "A+"-rated assets et cetera.[208] However, this "pecking order" may not be fully observed in reality for the following reasons. First, the model made borrowers' decision where to draw liquidity solely conditional upon haircuts, which were considered the exclusive determinant of repo conditions. Nonetheless, in reality, the six factors examined in Section 2.3 jointly determine repo conditions. Second, it was assumed that a continuum of borrowers was equipped with one bond each. In reality, borrowers usually own a portfolio of collateral at disposal and the decision concerning which of the assets to pledge may deviate from the pecking order derived above. Third, the repo market considerably contracted (Gorton and Metrick 2012, Krishnamurthy et al. 2014) and tightened collateral criteria (Cheun et al. 2009, ECB 2013a, Mancini et al. 2015) during times of financial

[207] Implications of adverse selection are derived for the credit quality of collateral in the following. Likewise, adverse selection is at work with respect to other asset properties such as liquidity.

[208] Likewise, in CQS 3, "BBB-"-rated assets are more likely pledged than "BBB"-rated assets, which in turn are more likely used than assets rated "BBB+".

Figure 5.20: Refined credit quality of inferred pledged collateral I

The figure refines the right panel in Figure 5.3 by elaborating on the distribution of collateral within CQSs, i.e. across credit rating notches. The left panel supposes that this distribution is uniform across rating notches and the right panel mirrors anecdotal evidence on the distribution of eligible marketable assets across rating notches (Figure 4.6). By comparison, the fraction of both high- ("AAA" and "AA") and lower-quality collateral ("A" and "BBB+") is larger in the right than the left panel.



Source: author's calculation; National Central Banks; European Central Bank, *Eligible Assets Database*.

distress, with the consequence that borrowers could have been constrained to pledge assets with the Eurosystem that they would have pledged in the market in normal times. Fourth, if there was no demand for specific assets in special repos, borrowers would have to pledge assets with the Eurosystem. Finally, the stigma of borrowing from the central bank may discourage owners of low-quality collateral to pledge with the central bank.[209] Hence, it is important to understand GLOC as a basic principle that gives rise to some degree of adverse selection of collateral rather than being fully observable in reality.

Therefore, Figure 5.21 presents different degrees of adverse selection of collateral. The left panel assumes adverse selection that is linear across credit rating notches, i.e. the fraction of pledged collateral decreases linearly with increasing credit quality within CQSs. The right panel illustrates the scenario in which adverse selection is progressive, i.e. the fraction of pledged collateral decreases degressively with increasing credit quality within CQSs. Average credit quality is lower in the latter scenario as the majority of pledged collateral is considered relatively low quality within each CQSs (i.e. "A-" and "BBB-"). Compared to the previous scenarios (Figure 5.20), the average credit quality of pledged collateral is estimated to have deteriorated owing to the adverse selection of collateral.

Sections 4.4 and 5.2.2 presented indicative evidence on adverse selection of collateral for the Eurosystem.[210] Figure 5.22 reaffirms the adverse selection between 2007 and 2013.[211] The

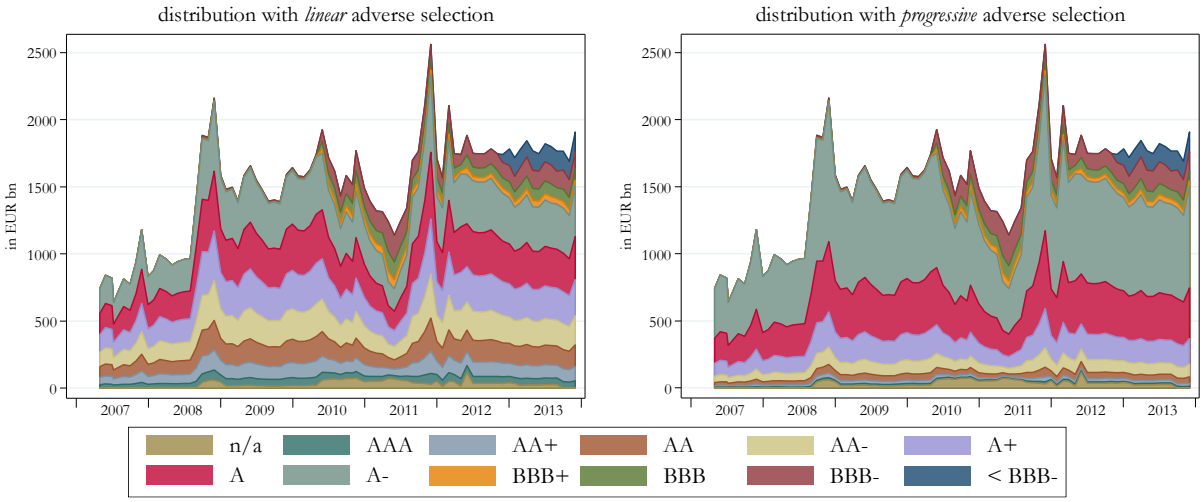
[209] On the stigma of central bank borrowing, see e.g. Allen and Moessner 2013, Armantier et al. 2013, Deutsche Bundesbank 2014 as well as Domanski et al. 2014.

[210] The former revealed that the average haircut (as a proxy of asset quality) on pledged collateral was considerably stronger than for eligible marketable assets, while the latter indicated that the decline of credit quality of pledged collateral was stronger for the Eurosystem than for the European repo market.

[211] See also Bindseil and Papadia 2006, Chailloux et al. 2008b and Nyborg 2015 for anecdotal evidence over different periods.

Figure 5.21: Refined credit quality of inferred pledged collateral II

The figure elaborates on the distribution of collateral across rating notches in due consideration of different degrees of adverse selection of collateral. The left panel assumes adverse selection that is linear across credit rating notches, i.e. the fraction of pledged collateral decreases linearly with increasing credit quality within CQSs. The right panel illustrates the scenario in which adverse selection is progressive, i.e. the fraction of pledged collateral decreases degressively with increasing credit quality within CQSs.



Source: author's calculation; National Central Banks; European Central Bank, *Eligible Assets Database*.

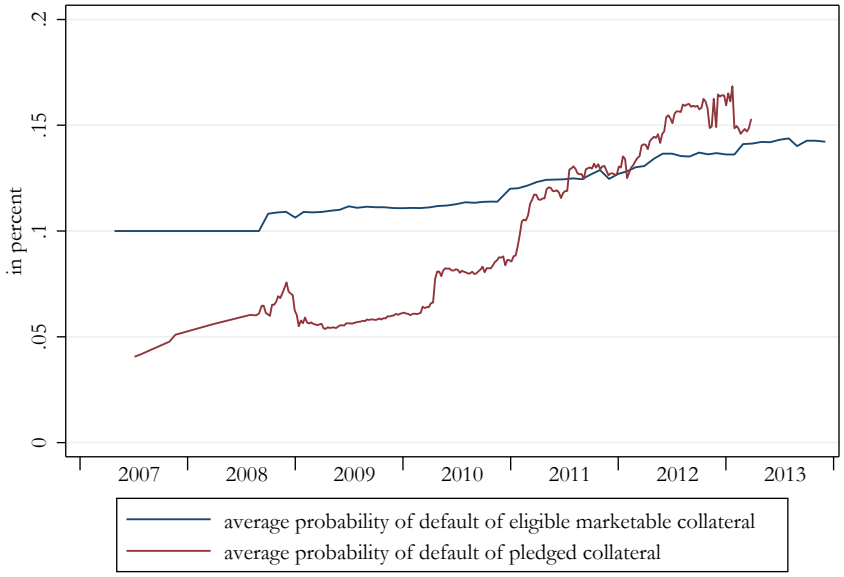
blue line details the average probability of default of eligible marketable assets and the red line illustrates the average probability of default of pledged collateral. The figure reveals that while the average default probability of eligible marketable increased subtly yet steadily from 0.1% in May 2007 to 0.14% in December 2013, the increase in the default probability of pledged collateral was stronger from 0.04% in August 2007 to 0.15% in April 2013. The average default probability of pledged collateral has outvalued that of eligible marketable assets as of October 2011. The potential narrative of this development is twofold: on the one hand, adverse selection of collateral gives an intuitive explanation for the asymmetric development of average default probabilities; and on the other, non-marketable assets have been increasingly pledged (Section 5.1). As these assets are not reflected by the blue line, the asymmetric development of default probabilities may to some extent be ascribed to the increased pledge of non-marketable assets. Therefore, the figure reveals that the default probability of pledged collateral substantially increased from 2007 to 2013. This increase can inter alia be attributed to relaxations of Eurosystem collateral criteria, the effects of which were amplified by the adverse selection of collateral.

The central bank attraction of specific tranches of eligible assets constitutes an effective market intervention with two broad effects (Chailloux et al. 2008b, Nyborg 2015). First, it affects asset markets as it influences commercial banks' asset-liability management decisions and tends to change relative prices for collateral assets. While the former could provide incentives for a larger level of liquidity leverage (Chailloux et al. 2008b), the latter gives rise to the overproduction of low-quality assets (Nyborg 2015).[212] Second, it makes central bank finances more prone to adverse shocks. The attraction of low-quality collateral would increase the Eurosys-

[212] Nyborg 2015 argues that the overproduction of illiquid assets is inefficient and may amplify business cycles. The author concludes that a central bank promoting this overproduction in a depressed economy impedes its recovery.

Figure 5.22: Avg. default probability (1-year horizon) of eligible marketable and pledged assets

The figure depicts the development of the average probability of default (over a one-year horizon) of eligible marketable assets (blue line) and pledged assets (red line). It provides indicative evidence concerning the adverse selection of collateral as the increase in the average default probability was larger for pledged collateral (from 0.04% in August 2007 to 0.15% in April 2013) than for eligible marketable assets (from 0.1% in May 2007 to 0.14% in December 2013).



Source: author's calculation; European Central Bank, *Eligible Assets Database*; ECB 2013c.

tem's risk exposure if additional collateral risk was not sufficiently hedged. Moreover, it affects the overall liquidity of the central bank balance sheet, which becomes less flexible. As central bank and government finances are naturally intertwined, the accumulation of low-quality assets in the central bank balance sheet has the potential to adversely affect government finances and hence it bears fiscal implications. Accordingly, fiscal implications of the Eurosystem collateral framework are addressed in depth in the following.

6

Framework for Analyzing the Fiscal Implications of Central Bank Collateral Criteria

This chapter introduces the framework for analyzing the fiscal implications of the Eurosystem collateral framework. These fiscal implications arise as amendments to collateral criteria induce dynamics in the government liability matrix, i.e. they cause the occurrence and transition of government liabilities. This is important in institutional settings with one government and one central bank. Importance is fostered in a monetary union where collateral criteria can have cross-country fiscal implications. Fiscal implications are analyzed within the framework of fiscal sustainability. The common framework of fiscal sustainability analysis under certainty is extended to uncertainty to factor in fiscal risk. Moreover, an intuitive indicator for assessing fiscal implications is derived. This indicator facilitates identifying sustainable and unsustainable fiscal policy stances and reflects necessary adjustments to fiscal policy induced by amendments to collateral criteria. The chapter is structured as follows. Section 6.1 introduces the concept of fiscal sustainability and argues that this concept is suitable for investigating the fiscal implications of collateral criteria. However, fiscal sustainability under certainty, as addressed in Section 6.2, fails to incorporate fiscal risk, which is vital to the analysis at hand and thus discussed in Section 6.3. Fiscal risk is introduced into the extended framework of fiscal sustainability analysis under uncertainty in Section 6.4. Moreover, this section derives an intuitive indicator for assessing fiscal implications of the collateral framework. Section 6.5 provides an overview of the fiscal implications of the Eurosystem collateral framework that are examined in depth in the following chapters.

6.1 The Concept of Fiscal Sustainability

The rationale for investigating the fiscal implications of central bank collateral criteria is the close (financial) connection between the central bank and the government. This connection originates from the institutional arrangement in which the government assigns banknote issuance to an operationally independent and specialized agency, i.e. the central bank. The central bank is linked to the government as the latter is usually the only or main shareholder of the former.[213] Accordingly, the central bank receives the right to issue the legal tender, while in return the government is entitled to receive (part of) the central bank's profit.[214] At the same time, the financial link also proceeds from the government to the central bank as the government implicitly backs the central bank through its ability to tax, which gives it the power to always recapitalize the central bank.[215] Based on this close connection, part of the literature calls for a consolidation of government and central bank budgets (Buiter 2004, 2007, Buiter and Rahbari 2012a).

The fiscal implications of collateral criteria may vary according to the time horizon. Consider e.g. potential effects of counterparty default on refinancing credit that is not sufficiently backed by collateral: the immediate effect on the government budget would be short-term as write-offs of central bank interest income implies a lower transfer to the government when write-offs are realized. However, the effect on the government budget would also be long term as counterparty default lastingly affects central bank interest income. The central bank cannot compensate for written-off refinancing credit without inducing inflation risk. Therefore, the short-term loss in interest income implies a long-term loss as interest income is permanently decreased for a given inflation rate.

Fiscal sustainability analysis provides a convenient technical framework to elaborate on the fiscal implications of collateral criteria over both the short- and long-term horizon. It examines whether the current fiscal policy stance can be maintained over time or whether adjustment is necessary to avoid debt levels that the government cannot bear. Therefore, the focus is usually not on default itself but rather on the policy changes necessary to avoid default. Consideration of the transfer from the central bank to the government facilitates the analysis of the fiscal implications of collateral criteria. Moreover, fiscal sustainability provides a suitable partial equilibrium framework to respect both the short- and long-term nature of the implications. The advantage of the partial equilibrium approach is that it highlights potential reliefs or constraints that amendments to collateral criteria may impose on fiscal policy. However, the application of this

[213] For instance, the shareholders of NCBs in the Eurosystem are the sovereigns, except for the Banque Nationale de Belgique, the Bank of Greece and the Banca D'Italia, which are listed on the stock market. See Buiter and Sibert 2005, Buiter 2008a, Cour-Thimann 2013 and Sinn 2015a. Potentially adverse effects of the close connection are investigated in e.g. Ize 2006 as well as Ize and Oulidi 2009. The separation must not be compromised in conducting monetary and fiscal policy. Central banks may be legally and financially linked to the government (and vice versa) but monetary policy is considered optimal when it is independent from fiscal policy, see Rogoff 1985, Persson and Tabellini 1993, Alesina and Gatti 1995, Fischer 1995, Walsh 1995 and Berger et al. 2001.

[214] See Hawkins 2003 as well as Sinclair and Milton 2011. As a discretionary distribution of central bank revenue to the government could be regarded as state financing through the central bank, rules are usually formally laid down for the transfer. See e.g. Hawkins 2003 for an overview of how this transfer is determined in several countries.

[215] The link is implicit as while the government is entitled to receive parts of central bank's profits, the study by Lönnberg and Stella 2008 finds that governments are usually not explicitly responsible for central bank obligations. This asymmetric treatment of profits and losses is further addressed in Chapter 7.

framework is connected with the common drawbacks of partial equilibrium, i.e. general equilibrium effects are neglected (Balassone and Franco 2000, Giammarioli et al. 2007, ECB 2011c). Specifically, the analysis leaves aside interactions between fiscal policy and economic variables.[216]

The concept of fiscal sustainability evolved from the extensive discussion of the effects of government debt on the economy, dating back to David Hume, Adam Smith and David Ricardo.[217] Concerns about the potential adverse effects of government debt were also raised by Domar 1944, who articulated that "[...] continuous government borrowing results in an ever-rising public debt, the servicing of which will require higher and higher taxes; and that the latter will eventually destroy our economy or result in outright repudiation of the debt" (cf. ibid., p. 799). Furthermore, ibid. was the first to formalize the idea of fiscal sustainability within a partial equilibrium framework in which the growth rate of the economy and the interest rate are exogenous.[218] ibid. investigates how the tax rate is affected by a perpetual public deficit that leads to a permanently increasing and unbounded stock of public debt. Taxes are exclusively levied for interest payments on issued bonds. The tax rate is applied to taxable income, defined as the sum GDP, and interest receipts on debt as the latter are also subject to taxation. The core result is that the debt-to-Gross Domestic Product (GDP) ratio converges to some constant value, which is determined by the relationship between the deficit (as a given fraction of GDP) and the growth rate of the economy. Moreover, even a perpetually growing level of debt does not lead to an ever-increasing tax rate. However, the crucial assumption is that the deficit is a constant fraction of GDP. As the growth rate of debt is finitely limited by the growth rate of GDP, the relation of debt to GDP is also finite. This relation assures the boundedness of the tax rate. The core result of ibid. can be regarded as the first formulation of a condition for fiscal sustainability based on which further approaches were subsequently formulated.

Table 6.1 provides an overview of the most common definitions of fiscal sustainability, which revolve around the idea that government solvency has to be maintained in the long run. While there is general agreement that solvency refers to the government's ability to service its debt obligations without explicitly defaulting, the government is considered to achieve long-term solvency in two ways: on the one hand, solvency is assured if fiscal policy gives rise to a bounded debt ratio in the long run, i.e. the debt ratio must not diverge. On the other hand, the government is considered solvent if it does not run a Ponzi scheme, i.e. a scheme in which it rolls over its entire debt in every period by issuing new debt. Two types of fiscal sustainability conditions can be identified in the literature based on the different interpretations of government solvency. According to Blanchard et al. 1990, the two types are summarized as follows:

i) "[...] a sustainable fiscal policy [is] [...] a policy such that the ratio of debt to Gross National Product (GNP) eventually converges back to its initial level" (p. 11);

ii) "[...] the present discounted value of the ratio of primary deficits to GNP [...] is equal to the negative of the current level of debt to GNP [...]" (p. 12).

[216] There is no general agreement on the theory governing this interaction. See e.g. Balassone and Franco 2000 as well as Chalk and Hemming 2000 for surveys of the literature.

[217] See e.g. Shaviro 1997 as well as Balassone and Franco 2000 for tracings of the discussion.

[218] This assumption neglects the notion that both factors depend on fiscal policy itself through e.g. crowding-out of private investment. Moreover, monetary considerations are left out as a constant price level is assumed.

These two conditions are treated as equivalent in Blanchard et al. 1990, although the second condition requires the present value of the debt ratio to converge to zero, which is consistent with the first condition as well as with any other finite debt ratio. Therefore, while the first condition implies the second, the second is necessary yet not sufficient for the first. It is apparent that the first condition is closely related to the core result in Domar 1944, i.e. the convergence of the debt ratio to some finite level. However, it is stricter as it requires the boundedness of the debt ratio to the initial level.

Table 6.1: Definitions of fiscal sustainability

The table surveys the most common definitions of fiscal sustainability, which revolve around the idea that government solvency has to be maintained in the long run.

Author(s)	Definition
Buiter 1985	Sustainable policy defined as one maintaining "a constant [...] ratio of public sector net worth to [...] output [...]." (p. 37)
Blanchard et al. 1990	"Sustainability is basically about good housekeeping. It is essentially about whether, based on the policy currently on the books, a government is headed towards excessive debt accumulation." (p. 8)
EC 2012	"Ability of a government to assume the financial burden of its debt in the future. Fiscal policy is not sustainable if it implies an excessive accumulation of government debt over time and ever increasing debt service." (p. 1)
ECB 2011c	"[...] [A] government's capacity to service its debt obligations in the long term." (p. 62)
IMF 2002	"An entity's liability position is sustainable if it satisfies the present value budget constraint without a major correction in the balance of income and expenditure given the costs of financing [...]." (p. 5)
OECD 2014	"Ability of a government to maintain public finances at a credible and serviceable position over the long term." (p. 50)

Source: author's compilation.

The (broad) second condition for fiscal sustainability as formulated in Blanchard et al. 1990 is applied in the following to elaborate on the fiscal implication of collateral criteria. This fiscal implication is investigated in terms of necessary changes to fiscal policy to sustain government solvency. The condition evolves from simple accounting identities of the government budget and is technically derived in the following.[219,220]

[219] The budget identity of the government has been a familiar component of dynamic macroeconomic models at least since the late-1960s; see e.g. Christ 1968 as well as Blinder and Solow 1973. It was earlier recognized within a broader context in e.g. Patinkin 1956, Hansen 1958 and Musgrave 1959. Later, Barro 1979 formulated the version of the budget identity that is still used in current fiscal sustainability analyses.

[220] It is necessary to define variables to subsume empirical counterparts when elaborating on accounting identities. For instance, the scope of the government sector as well as the adequate debt measure need to be defined. See e.g. Balassone and Franco 2000 for a discussion and Dippelsman et al. 2012 for an overview of different scopes of the government sector as well as debt measures.

6.2 Fiscal Sustainability under Certainty

Four steps are taken in the following to elaborate an intuitive measure according to which qualitative statements are made concerning the fiscal implications of amendments to collateral criteria. First, the budget identity of the government, i.e. the identity of revenue and expenditure in a given period, is specified. Second, the period budget identity is solved recursively to derive the relation between past, present and future budgetary items. The identity is formulated in present-value terms to make expressions comparable over different periods. Third, imposing a transversality condition (TVC) (or no-Ponzi game condition (NPG), see e.g. Blanchard and Fischer 1989, Chalk and Hemming 2000 and Giammarioli et al. 2007) to the government turns the present-value budget identity into a *constraint* to the government. The intuitive measure for assessing the fiscal implications of collateral criteria is derived from the present-value budget constraint (PVBC) in the final step.

Period Budget Identity of the Government

The analysis is performed within the budgetary framework of a government in a closed economy.[221] The budget identity of the form still used in fiscal sustainability analysis was developed by Barro 1979. It is extended to incorporate the transfer from the central bank to the government.[222] The government has to generate revenue to finance its expenditure G, e.g. in providing services that the market fails to efficiently provide.[223] The government generates revenue from three sources. Foremost, revenue is raised via taxation, which gives tax revenue to the amount of T. Second, the government can borrow by issuing one-period bonds to the amount of D against paying the interest rate $i > 0$. Third, the government receives transfer from the central bank, denoted by Γ. The flow budget identity of the government in period $t+1$ is given by

$$G_{t+1} + i_{t+1}D_t = T_{t+1} + (D_{t+1} - D_t) + \Gamma_{t+1}. \tag{6.1}$$

Rearranging Equation (6.1) gives the law of motion of the government debt-to-GDP ratio.[224] With $Y_{t+1} = (1 + g_{t+1})Y_t$ and $P_{t+1} = (1 + \pi_{t+1})P_t$ where Y is GDP, P the price level, g the growth rate of GDP and π the inflation rate, this law of motion reads as

$$\frac{D_{t+1}}{P_{t+1}Y_{t+1}} = \frac{(1 + i_{t+1})}{(1 + \pi_{t+1})(1 + g_{t+1})}\frac{D_t}{P_tY_t} - \frac{(T_{t+1} - G_{t+1})}{P_{t+1}Y_{t+1}} - \frac{\Gamma_{t+1}}{P_{t+1}Y_{t+1}}. \tag{6.2}$$

[221] The assumption of a closed economy rules out concerns about complications created by external debt, i.e. debt owed to non-residents, as well as debt denominated in foreign currency.

[222] See among others Uctum and Wickens 2000, Burnside 2005a,b and Ley 2010. This transfer mainly originates from interest income from money creation, which has been an important source of government revenue, see e.g. Dornbusch 1988, Giavazzi and Giovannini 1989, Cukierman et al. 1992, Gros 1993, Sinn and Feist 1997, 2000, Sims 2004 and Vergote et al. 2010. The importance of central bank interest income in the context of the European sovereign debt crisis has been emphasized by Buiter and Rahbari 2012a, Sinn 2012, 2014b as well as Pâris and Wyplosz 2014.

[223] According to the "Selection Principle" (Sinn 1997), governments should provide those services that are unsuitable for private markets such as public infrastructure goods and social insurance

[224] The importance of analyzing relative measures of government debt was first recognized in Hansen 1941 and Domar 1944.

As the real interest rate is given by $1 + r \equiv \frac{1+i}{1+\pi}$, Equation (6.2) can be simplified to[225]

$$d_{t+1} = \frac{1 + r_{t+1}}{1 + g_{t+1}} d_t - pb_{t+1} - \gamma_{t+1}, \tag{6.3}$$

with pb_{t+1} being the primary balance, i.e. tax revenue minus government expenditure relative to nominal GDP, and d as well as γ the corresponding upper-case variables relative to nominal GDP. Accordingly, γ_{t+1} gives the transfer from the central bank to the government in period $t + 1$. Equation (6.3) always holds as it is derived from accounting identities. Per se, there is no reason for r and g to be exogenous, but since the framework is partial equilibrium, effects of fiscal policy on r and g are neglected.[226]

Present-Value Budget Identity of the Government

While the flow budget identity is useful for assessing the stance of fiscal policy in a given period, it fails to highlight the dynamic nature of government budgeting (see e.g. Poterba 1997). Therefore, Equation (6.3) is solved recursively to derive the deterministic present-value budget identity. Hence, the present value of the debt ratio in period $t + j$ is given by the following standard solution of the first-order difference equation:

$$\prod_{k=1}^{j} \left(\frac{1 + r_{t+k}}{1 + g_{t+k}}\right)^{-1} d_{t+j} = d_t - \sum_{j=0}^{\infty} \prod_{k=1}^{j} \left(\frac{1 + r_{t+k}}{1 + g_{t+k}}\right)^{-1} pb_{t+j} - \sum_{j=0}^{\infty} \prod_{k=1}^{j} \left(\frac{1 + r_{t+k}}{1 + g_{t+k}}\right)^{-1} \gamma_{t+j}. \tag{6.4}$$

Equation (6.4) shows that d_{t+j} is determined by the following three factors: *(i)* initial debt (i.e. the debt ratio in period t), *(ii)* the present value of primary balances and *(iii)* the present value of transfers from the central bank.

Present-Value Budget Constraint (PVBC) of the Government

The present-value budget *constraint* of the government is subsequently derived in two steps. First, Equation (6.4) is rearranged under the assumption that time goes to infinity, which gives

$$\begin{aligned} \lim_{j\to\infty} \prod_{k=1}^{j} \left(\frac{1 + r_{t+k}}{1 + g_{t+k}}\right)^{-1} d_{t+j} = d_t &- \lim_{j\to\infty} \sum_{j=0}^{\infty} \prod_{k=1}^{j} \left(\frac{1 + r_{t+k}}{1 + g_{t+k}}\right)^{-1} pb_{t+j} \\ &- \lim_{j\to\infty} \sum_{j=0}^{\infty} \prod_{k=1}^{j} \left(\frac{1 + r_{t+k}}{1 + g_{t+k}}\right)^{-1} \gamma_{t+j}. \end{aligned} \tag{6.5}$$

A TVC is imposed to the left-hand side of Equation (6.5), i.e. the present value of the debt ratio when times goes to infinity, to receive a constraint for the government budget. In principle, this

[225] The real interest rate can be expressed as $r = (i - \pi)/(1 + \pi)$. It is known from the Fisher equation that this is accurately approximated by $r \approx i - \pi$ when both i and π are sufficiently small. To circumvent a tedious discussion about dynamic (in)efficiency, it is assumed that $r > g$ in the remainder, i.e. the case of dynamic efficiency is considered. A dynamically inefficient economy would never have a sustainability problem as the growth rate of the economy would exceed the interest rate on government debt. See e.g. Phelps 1961, Allais 1962 and von Weizsaecker 1962 on dynamic (in)efficiency. See e.g. Diamond 1965, Spaventa 1987, Blanchard 1990, Blanchard et al. 1990, Bartolini and Cottarelli 1994, Bohn 1995 and Blanchard and Weil 2001 for the role of dynamic (in)efficiency in the context of public debt and fiscal sustainability.

[226] The limitations are put forward by e.g. Musgrave and Musgrave 1984, Masson 1985 and Weil 1987.

present value could be *(i)* smaller than, *(ii)* greater than or *(iii)* equal to zero. The first case would imply that when time goes to infinity, the government holds an asset as private agents are indebted with the government. This can be ruled out for a rational government. Instead, *(ii)* would imply that the government runs a Ponzi scheme in which it rolls over its debt in every period by issuing new debt.[227] O'Connell and Zeldes 1988 show that this is not feasible with a finite number of agents as it would imply that some individual holds government debt at some infinite point in the future, whereas this individual would be better off in at least one period by not holding such debt. Therefore, holding debt that is continuously rolled over is strictly dominated by holding no debt at all, which prohibits the government from running a Ponzi scheme. The imposition of the TVC requires the left-hand side of Equation (6.5) to be equal to zero, i.e.

$$\lim_{j\to\infty} \prod_{k=1}^{j} \left(\frac{1+r_{t+k}}{1+g_{t+k}}\right)^{-1} d_{t+j} = 0. \tag{6.6}$$

Requiring that the TVC holds is generally regarded as the conventional condition for the government remaining solvent in infinite time. Imposing the TVC transforms the present-value budget *identity* to the deterministic present-value budget *constraint*, given by

$$d_t = \lim_{j\to\infty} \sum_{j=0}^{\infty} \prod_{k=1}^{j} \left(\frac{1+r_{t+k}}{1+g_{t+k}}\right)^{-1} pb_{t+j} + \lim_{j\to\infty} \sum_{j=0}^{\infty} \prod_{k=1}^{j} \left(\frac{1+r_{t+k}}{1+g_{t+k}}\right)^{-1} \gamma_{t+j}. \tag{6.7}$$

Equation (6.7) stipulates the initial debt ratio to be offset by the present value of all future revenue of the government.[228] Accordingly, the government has to finance its initial debt from *(i)* primary balance and *(ii)* transfers from the central bank. Running temporary primary deficits would be consistent with Equation (6.7) as long as they are compensated for by sufficiently high surpluses in other periods.[229]

The fiscal theory of the price level (FTPL) interprets Equation (6.7) from a different perspective:[230] if initial debt and the present value of future surpluses do not match in real terms for a given price level, then the price level adjusts to restore equilibrium as government spending induces a change in the price level through its effect on aggregate demand. Hence, the FTPL turns a constraint on the government budget into a macroeconomic equilibrium condition. However, this theory is subject to persistent critique (e.g. Buiter 2002, 2005, and Bohn 2008). It is claimed that the PVBC should always be satisfied (and not only in equilibrium) and that the FTPL implicitly allows the government to pursue time-inconsistent policy.

[227] Ponzi scheme refers to a scheme in which individuals pay out funds to some parties by borrowing these funds from others. It dates back to Charles Ponzi, who ran such a scheme in the early 20th century (e.g. Russel 1973).

[228] A weaker condition of fiscal sustainability demands stationarity of the debt ratio, cf. e.g. Bartolini and Cottarelli 1994 as well as Haber and Neck 2008.

[229] Abstracting from central bank transfers, McCallum 1984 points out that permanent primary deficits would be inconsistent with the PVBC if initial debt is positive, as this would imply a Ponzi scheme. Likewise, the government could not run a small primary deficit followed by a primary balance equal to zero.

[230] See e.g. Leeper 1991, Sims 1994, Woodford 1995, Canzoneri et al. 2001 and Cochrane 2001 for the FTPL.

Reinterpretation of Equation (6.7) within the FTPL is closely connected to the general literature on the relationship between fiscal and monetary policy.[231] The literature recognizes that both the fiscal and the monetary authority can contribute to satisfying the PVBC. The fiscal authority can adjust *pb* and the monetary authority can alter γ. A situation in which fiscal policy is expected to adjust its policy stance to ensure that the PVBC is balanced while the monetary authority sets its policy freely (i.e. γ in this context) is referred to as *monetary dominance* or a *Ricardian* regime. By contrast, a *non-Ricardian* regime with *fiscal dominance* assumes the monetary authority to ensure that the PVBC is met by adapting the transfer to the government. Developments in the Eurozone since the onset of the sovereign debt crisis suggest that such a clear-cut distinction between the two regimes may not be observable in reality.[232] Developments indicate a (at least) partial shift from monetary dominance to a (partial non-Ricardian) regime of quasi-fiscal dominance as the Eurosystem became a major player in managing the debt crisis, adapting its monetary policy to assume quasi-fiscal activities and support government budgets under distress.[233]

Evaluation of Fiscal Sustainability

The PVBC given by Equation (6.7) serves as the benchmark against which fiscal sustainability is qualitatively evaluated in the following.[234] Fiscal sustainability is evaluated for an economy in a steady state, i.e. *(i)* the real interest rate and the growth rate of the economy are constant ($r_{t+k} = r$ and $g_{t+k} = g$), *(ii)* the primary balance is time-invariant ($pb_{t+j} = pb$) and *(iii)* the transfer from the central bank to the government is constant, i.e. $\gamma_{t+j} = \gamma$. Hence, Equation (6.7) can be simplified to

$$d \leq \sum_{j=1}^{\infty} \left(\frac{1+r}{1+g} \right)^{-j} (pb + \gamma) \,. \tag{6.8}$$

Fiscal policy is considered sustainable if the sum of present values of primary balance and transfer from the central bank are equal to or greater than the debt ratio. Under the assumption of dynamic inefficiency ($r > g$), steady-state dynamics of the debt ratio are implied by the sustainability condition[235]

$$d \leq \frac{1+g}{r-g} (pb + \gamma) \,. \tag{6.9}$$

[231] See among others Aiyagari and Gertler 1985, Leeper 1991, Sargent and Wallace 1981, King and Plosser 1985, Cochrane 2001, Afonso 2008, Ize and Oulidi 2009 as well as Walsh 2010.

[232] See e.g. Afonso 2008 for an empirical investigation and a comprehensive overview of previous studies.

[233] Therefore, weak fiscal dominance is considered in Chapter 7 when the preferences of the government over the level of collateral criteria are examined. If the monetary authority takes into account the government's preferences, the government still seeks to adjust primary balance to meet the PVBC but is supported by the monetary authority.

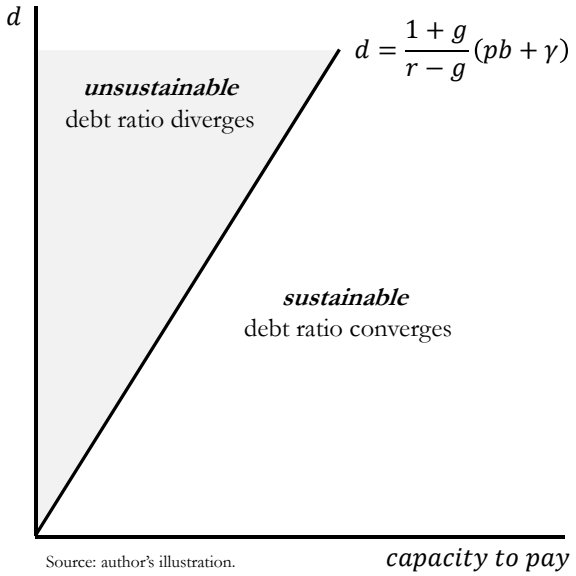
[234] The PVBC is also central to the quantitative assessment of fiscal sustainability within two extensive strands of literature. On the one hand, it has served as the basis of various indicators of fiscal sustainability. See among many others Blanchard 1990, Blanchard et al. 1990, Langenus 2006, Giammarioli et al. 2007 and Balassone et al. 2009. On the other hand, empirical tests have been elaborated based on the PVBC, see e.g. Hamilton and Flavin 1986, Trehan and Walsh 1991, Wilcox 1989, Hakkio and Rush 1991, Bohn 1998, Papadopoulos and Sidiropoulos 1999, Afonso 2005, Burnside 2005a, Bohn 2008, Mendoza and Ostry 2008 as well as Potrafke and Reischmann 2015. For discussions of both strands, see e.g. Balassone and Franco 2000, Chalk and Hemming 2000 as well as Neck and Sturm 2008. However, no quantitative assessment of fiscal sustainability will be made here.

[235] Outside steady state, Equation (6.9) could still be equivalent to Equation (6.7) if steady-state values are interpreted as averages (Burnside 2005a). Moreover, $\sum_{j=1}^{\infty} ((1+r)/(1+g))^{-j}$ only converges for $r > g$ but diverges otherwise.

The interpretation of $pb + \gamma$ as the government's *capacity to pay* facilitates the analysis of debt dynamics inherent in Condition (6.9) (cf. Bartolini and Dixit 1991, Miller and Zhang 2000) that are stylized in Figure 6.1. The sustainability frontier determined by Condition (6.9) and reflected by the solid line is decisive for evaluating fiscal sustainability. Combinations of $pb + \gamma$ and d to the right of the solid line are considered sustainable as the debt ratio converges (white area) while all combinations to the left are deemed unsustainable as the debt ratio diverges (gray area). The gray area is inter alia determined by the growth rate-interest rate differential $r - g$. The smaller $r - g$, the steeper the sustainability frontier and hence the smaller the gray area, i.e. less combinations of $pb + \gamma$ and d are deemed unsustainable. By contrast, the sustainability frontier is flat for large $r - g$, such that more combinations of $pb + \gamma$ and d are considered unsustainable.

Figure 6.1: Fiscal sustainability and debt dynamics under certainty

The figure reflects Condition (6.9) and illustrates inherent debt dynamics. The sustainability frontier given by the solid line is decisive for evaluating fiscal sustainability. Combinations of $pb + \gamma$ and d to the right are considered sustainable as the debt ratio converges (white area), while all combinations to the left are deemed unsustainable as the debt ratio diverges (gray area).



Source: author's illustration.

Moreover, Condition (6.9) can be used to evaluate fiscal sustainability in two ways (Burnside 2005a). First, the steady-state level of d can be determined based on assumptions for r, g, pb and γ. Government finances are deemed unsustainable if the actual d exceeds this steady-state level. Second, under the assumption that a rationale government chooses the lowest primary balance deemed sustainable, Condition (6.9) holds with equality and can be solved for the primary balance such that

$$pb^* = \frac{r - g}{1 + g} d - \gamma. \tag{6.10}$$

Equation (6.10) serves as a straightforward indicator of fiscal sustainability.[236] It determines the primary balance that is at least necessary to ensure fiscal sustainability in steady state, i.e.

[236] Fiscal sustainability indicators of the EC are akin to pb^*. The indicators measure the gap between the debt-stabilizing and the actual primary balance for different time horizons. See Balassone et al. 2009 and EC 2012. See Bartolini and Cottarelli 1994, Papadopoulos and Sidiropoulos 1999, Barnhill and Kopits 2005, Burnside 2005a as well as Balassone et al. 2009 for further applications.

the primary balance necessary to stabilize the debt ratio. It depends on the interest rate-growth rate differential, the debt ratio and the transfer from the central bank. The larger the interest rate-growth rate differential and the initial debt ratio or the lower the transfer from the central bank, the larger the required debt-stabilizing primary balance.

The indicator provided by Equation (6.10) is used in the following to analyze the fiscal implications of central bank collateral criteria in terms of the *qualitative* development of pb^*. No statement on the *quantitative* development of pb^* is made. This restriction is due to acknowledging the simple form of the indicator and the assumptions necessary to derive it. Furthermore, insights are subject to the flaws of any fiscal sustainability indicator (see Giammarioli et al. 2007), e.g. the necessity to quantify factors over an infinite time horizon, usually based on exogenous assumptions on macroeconomic variables.

Another shortcoming of sustainability indicators developed in a deterministic environment is that they fail to recognize potential adverse effects to fiscal sustainability under uncertainty. Policies that appear sustainable in a certain world may no longer be so under uncertainty (Bohn 1991, 1995). However, the effects of uncertainty are particularly important for fiscal sustainability owing to the infinite time horizon inherent to the analysis.

6.3 The Concept of Fiscal Risk

Thus far, the government has been assumed to have deterministic income and expenditure flows such that the fiscal outcome is fully predictable and expectations on this outcome are always met. This may no longer hold when uncertainty is introduced, giving rise to fiscal risk. Cebotari et al. 2009 define fiscal risk as the possibility of fiscal outcomes to deviate from what was expected. Deviations can be the result of variations in both income and expenditure flows. For the purpose of the analysis, the focus is placed upon variations in expenditure flows.[237] This section addresses the concept of fiscal risk, which evolves around the *government liability matrix* dating back to Brixi 1998.[238] The concept is presented and discussed in general and with respect to the qualitative analysis of the fiscal implications of the collateral framework.[239]

Government Liability Matrix

The government liability matrix is depicted in Table 6.2 and recognizes the uncertainty of government liabilities with respect to amount and maturity. Uncertainty with respect to amount is implied by the differentiation between "explicit" and "implicit" liabilities, while uncertainty with respect to maturity is considered by distinguishing between "non-contingent" (or direct)

[237] See Brixi and Mody 2002 for a comprehensive analysis based on an extended asset and liability management framework. For the extended government balance sheet upon which this framework bases, see e.g. Cassard and Folkerts-Landau 1997, Currie and Velandia 2002 as well as World Bank and IMF 2014.

[238] The matrix is a common approach to structure liabilities of the government, see e.g. Brixi and Mody 2002, Brixi 2005, Giammarioli et al. 2007, Das et al. 2012 as well as IMF 2013. See IMF 2005 and Dippelsman et al. 2012 for another systematization with respect to the degree of certainty of government liabilities.

[239] The discussion is limited to the extent that it does not present a framework for the disclosure as well as the statistical and accounting treatment of uncertain government income and expenditure flows. See IMF 2014b for the statistical treatment and IFAC 2014 for accounting. Furthermore, the question of fiscal risk management is only addressed conceptually, see Brixi and Mody 2002, Cebotari et al. 2009 as well as IMF 2013 for in-depth investigations.

and "contingent" liabilities. Differentiation between explicit and implicit liabilities bases on the origin of liabilities. Explicit liabilities are contractually agreed such that the amount can be determined with certainty, corresponding to the face value stipulated by contract. By contrast, implicit liabilities are not contractually agreed but originate from expectations by e.g. the public or interest groups. Hence, while the government is not legally obliged to act upon such liabilities, it is expected to do so. As expectations are usually based on past practices, implicit liabilities are particularly important in the long run and must not be neglected in fiscal sustainability analysis. Differentiation between non-contingent and contingent liabilities bases on maturity. Non-contingent liabilities are liabilities that mature in any case. However, liabilities can also mature depending on the occurrence of a specific event. These liabilities are called contingent liabilities and they are usually neglected in conventional government budget analysis and accounting.

The combination of the two dimensions of uncertainty gives the four types of liabilities stated in Table 6.2, i.e. *(i)* non-contingent explicit liabilities, *(ii)* non-contingent implicit liabilities, *(iii)* contingent explicit liabilities and *(iv)* contingent implicit liabilities. *Non-contingent explicit liabilities* are liabilities that are legally enforceable by the obligee as they are stipulated by contract or law and that mature in any case, i.e. maturity does not depend on particular events. Government debt, i.e. debt instruments issued by the government, is the conventional non-contingent explicit liability.[240] In addition, this type of government liability comprises legally enforceable government expenditure commitments established e.g. in the annual government budget plan. In many countries, such commitments also include unfunded and clearly defined pension payments.By contrast, *non-contingent implicit liabilities* mature in any case but are not legally enforceable by the obligee as they are not stipulated by law or contract. Despite not being legally binding, such liabilities are expected to be settled in certain cases, such as future social welfare payments. Social welfare payments stemming from a pay-as-you-go pension scheme are the prime example of a non-contingent implicit liability. Therefore, they are often considered in determining the "implicit debt" of the government (see Sinn 2000 as well as Moog and Raffelhüschen 2012; cf. Auerbach et al. 1999 as well as Kotlikoff and Raffelhüschen 1999 for estimates of implicit debt). Another type is payments related to recurrent operations such as the refurbishment of the economy's capital stock.

By contrast, contingent liabilities only mature in case a specific event occurs. Therefore, they are often considered as fiscal risk, treated as off-balance-sheet items and undiscounted in conventional budgeting.[241] In case of maturity, contingent liabilities may pose an adverse shock to the government budget. The clear-cut example of *contingent explicit liabilities* is government individual guarantees on debt issued by public and private entities. Moreover, explicit contingent liabilities can result from government umbrella guarantees and insurance schemes on e.g.

[240] A different view is presented in Grossman and van Huyck 1988, where government debt is considered uncertain as the government may have to reduce or suspend debt service in bad states of the world, i.e. if certain contingencies arise. The government can "excusably" default, i.e. default that is justifiable and accepted by creditors owing to the contingency, without damaging capital market access. By contrast, it would be punished if default was unjustifiable and inexcusable.

[241] Even if they are taken into account in budgeting, contingent liabilities are complex arrangements that are difficult to quantify. Therefore, no single measurement approach can fit all situations and comprehensive approaches are still evolving, see IMF 2013.

Table 6.2: Government liability matrix

The table implies the four types of government liabilities that originate from the combination of the two dimensions of uncertainty, i.e. *(i)* non-contingent explicit liabilities, *(ii)* non-contingent implicit liabilities, *(iii)* contingent explicit liabilities and *(iv)* contingent implicit liabilities.

Type of Liability	Non-Contingent not depending on realization of particular event	Contingent depending on realization of particular event
Explicit legally binding	non-contingent but legally binding liabilities like • **debt instruments issued**[a] • expenditure commitments established in the annual budget plan	both contingent and legally binding liabilities from • **government individual guarantees** (on debt issued by public or private entities)[b] • government umbrella guarantees (e.g. on household mortgages) • **government insurance schemes** (e.g. on bank bonds, bank deposits, returns from private pension funds)[b]
Implicit not legally binding but originating from public and/or interest group expectations and pressure	neither contingent nor legally binding liabilities like • future social welfare payments • future expenditures related to recurrent operations	contingent but not legally binding liabilities from • **bailout of defaulting public or private sector entities**[b] • **central bank bailout**[c] • disaster relief • environmental damage • military financing

[a] addressed in Chapters 7 and 8.
[b] addressed in Chapter 8.
[c] addressed in Chapter 7.
Source: author's compilation; adapted from Brixi 1998 and Das et al. 2012. See IMF 2013 for a comprehensive version of the matrix.

bank deposits and returns of private pension funds. *Contingent implicit liabilities* are usually triggered by the default of a public or private entity that the government has to bail out. Furthermore, the government may have to assume financial responsibility for the central bank when the central bank balance sheet is under distress. It is also expected to bear the cost of disaster relief and environmental damage, as well as financially backing the military. Contingent explicit and implicit liabilities as fiscal risk are further examined in the following given their importance to the analysis.

Contingent Explicit Liabilities Contingent explicit liabilities are defined as legal or contractual obligations that give rise to payments if one or more stipulated conditions arise (UN 2009). Owing to the legal or contractual a priori agreement, only the occurrence of the contingent explicit liability is uncertain, while the value at risk is known to the government. Contingent explicit liabilities have repeatedly proven a severe threat to the government budget in the past. Contingent explicit liabilities often take the form of guarantees to public and private sector entities. Different types of government guarantees exist.[242] While there are government individual guarantees granted to debt instruments of beneficiaries on an individual basis, the government also gives umbrella guarantees to specific types of debt instruments and/or specific issuer groups such as household mortgages and student loans. Moreover, a very broad form of guarantee is issued by the government as insurance schemes. Such schemes can take the form of insurance of bank deposits, insurance against losses from e.g. crop failures and natural disasters, insurance of a minimum return from private pension funds or war-risk insurance. Typically, government insurance schemes cover risk deemed uninsurable by the private insurance industry, specifically low-probability high-impact events (see Kunreuther 1997, Cutler and Zeckhauser 1999 as well as Eberl and Jus 2012). In particular, government guarantees and insurance issued to the financial sector has proved a substantial source of fiscal risk in terms of contingent explicit liabilities, as the recent financial crisis revealed.[243] For the recent financial crisis (2007 to 2009), Laeven and Valencia 2014 estimate the median direct fiscal costs, i.e. fiscal outlays committed to the financial sector that capture direct fiscal implications of public intervention, in various advanced and emerging economies of 4.9% of GDP and the median increase in the debt ratio at 23.9%. Therefore, direct fiscal costs were lower (compared to 10% of GDP for crises between 1970 and 2006), although the increase in the debt ratio was larger (relative to 16.3%). However, the fiscal costs of financial crises were not exclusively due to explicit government action but also the result of government contingent implicit liabilities.

Contingent Implicit Liabilities Contingent implicit liabilities are obligations that do not arise from a legal or contractual source but are recognized after a condition or event is realized. These liabilities often exceed explicit ones if due as the government and the beneficiary did not agree on a specific value at risk. The guarantee has no face value and its value depends on

[242] See IMF 2005 for an extensive study of government guarantees as fiscal risk. See IMF 2013 for a condensed overview of the different types of government guarantees.

[243] See e.g. Laeven and Valencia 2008, 2012, 2014, Claessens et al. 2014 as well as Reinhart and Rogoff 2014 for analyses of the impact of the recent yet also historic systemic banking crises inter alia on the government budget.

past practice and expectations. Therefore, both occurrence and value at risk are uncertain.[244] Most importantly, contingent implicit liabilities emerge from the bailout of defaulting public and private sector entities. This is especially the case for the financial sector, for which bailing out illiquid/insolvent banks contributed to the fiscal costs of crisis and the rise in debt ratios (see above). Bailout beyond contractual obligations is extensively discussed with respect to financial institutions that are considered too big to fail (TBTF).[245] Moreover, the government does not have the legal obligation to financially support its central bank in times of financial distress. However, if the central bank might struggle to fulfill its monetary policy mandate, the government may provide financial support.[246] Akin guarantees that may result in a bailout of companies are implicitly given to certain industries. The clear-cut example is the nuclear industry, for which governments usually assume financial responsibility beyond contractual or legal obligations in case of disaster.[247] Accordingly, governments are expected to assume financial responsibility for disaster relief and environment damage.

Liabilities are not static within Table 6.2 as movements within the matrix are possible. For instance, the government could reduce the tax contribution to the social security system, which ceteris paribus would transform explicit into non-contingent implicit liabilities. Likewise, the government often has to issue new debt to finance the social security system, which would turn non-contingent implicit liabilities explicit. A systemic banking crisis can result in implicit guarantees to the financial sector being made explicit as well as financial institutions being bailed out by the government. If the government bore the cost by issuing new debt, the former contingent explicit and implicit liabilities would lead to non-contingent explicit liabilities. Dynamics within the matrix triggered by government intervention to bail out the central bank and mitigate implicit guarantees to the financial sector by issuing new debt are addressed in Chapters 7 and 8, respectively.

6.4 Fiscal Sustainability under Uncertainty

The basic framework of fiscal sustainability analysis is extended to incorporate fiscal risk in terms of contingent explicit and implicit liabilities. The framework is modified in two ways when uncertainty is taken into account.[248] First, future values of variables may vary across different states of the world such that values are expressed in terms of expected values. Second, contingent explicit and implicit liabilities are factored in.

The literature proposes different approaches to investigate fiscal sustainability under uncertainty, differing with respect to the task assigned to fiscal sustainability analysis.[249] Mendoza and

[244] Behavioral implications of implicit guarantees such as moral hazard from de facto limited liability may increase the value at risk, as addressed in e.g. Sinn 1980, 1983 and Shavell 1986.

[245] For discussions and estimates for different countries and time periods, see Baker and McArthur 2009, Kelly et al. 2012, Ueda and Weder di Mauro 2012, Tsesmelidakis and Merton 2012, Araten and Turner 2013, Acharya et al. 2014a as well as IMF 2014.

[246] The contingent implicit liability from central bank bailout is addressed in depth in Chapter 7.

[247] See Eberl and Jus 2012 for the implicit guarantee to the nuclear industry and a proposal for optimal regulation.

[248] Bohn 1995 proposes a third way, claiming that the marginal rate of substitution between different points in time has to be used for discounting under uncertainty, see also Chalk and Hemming 2000. However, this issue is predominantly relevant for empirical investigations and is neglected here for the sake of technical convenience.

[249] See Burnside 2004 for a discussion and assessment of various approaches.

Oviedo 2006 consider uncertainty in revenue flows of governments in emerging market economies and investigate how this affects the government's ability to borrow. Xu and Ghezzi 2003 model flows in the government budget identity as stochastic processes to estimate default probabilities. Approaches by the IMF such as IMF 2003 and 2013 allow for uncertainty to generally enhance the assessment of prior fiscal policy records and discussion of future policy choices. Finally, Barnhill and Kopits 2005 assess fiscal risk from contingent liabilities by measuring government net worth from a stochastic process. Based on the valuation of contingent liabilities and their effect on the government budget, the study evaluates the probability of the net worth becoming negative.

A more general and stylized approach to fiscal sustainability analysis under uncertainty is developed in the following. The deterministic PVBC given by Equation (6.7) is formulated in expected value terms and contingent liabilities are taken into account to derive the stochastic PVBC. Based on this stochastic formulation, the simple indicator for assessing fiscal sustainability is extended to reflect uncertainty.

Present-Value Budget Constraint Revisited

Based on Equation (6.3), which gives the government budget identity under certainty, the budget identity under uncertainty is given by taking expectations as from time $t+1$ such that

$$\mathbb{E}_t[d_{t+1}] = \frac{1+\mathbb{E}_t[r_{t+1}]}{1+\mathbb{E}_t[g_{t+1}]} d_t - \mathbb{E}_t[pb_{t+1}] - \mathbb{E}_t[\gamma_{t+1}], \tag{6.11}$$

with $\mathbb{E}_t[\cdot]$ denoting the expectations operator conditional on information available at time t. Solving Equation (6.11) recursively and assuming infinite time gives

$$\begin{aligned} \lim_{j\to\infty} \mathbb{E}_t \prod_{k=1}^{j} \left(\frac{1+r_{t+k}}{1+g_{t+k}}\right)^{-1} d_{t+j} = d_t &- \lim_{j\to\infty} \mathbb{E}_t \sum_{j=0}^{\infty} \prod_{k=1}^{j} \left(\frac{1+r_{t+k}}{1+g_{t+k}}\right)^{-1} pb_{t+j} \\ &- \lim_{j\to\infty} \mathbb{E}_t \sum_{j=0}^{\infty} \prod_{k=1}^{j} \left(\frac{1+r_{t+k}}{1+g_{t+k}}\right)^{-1} \gamma_{t+j}, \end{aligned} \tag{6.12}$$

which is the analogue of Equation (6.5) under uncertainty, i.e. the present-value budget identity with uncertainty about future realizations of debt, primary balances and transfers from the central bank.

Imposing the TVC, i.e. assuming that the left-hand side of Equation (6.12) is equal to zero,[250] gives the stochastic PVBC as

$$d_t = \lim_{j\to\infty} \mathbb{E}_t \sum_{j=0}^{\infty} \prod_{k=1}^{j} \left(\frac{1+r_{t+k}}{1+g_{t+k}}\right)^{-1} pb_{t+j} + \lim_{j\to\infty} \mathbb{E}_t \sum_{j=0}^{\infty} \prod_{k=1}^{j} \left(\frac{1+r_{t+k}}{1+g_{t+k}}\right)^{-1} \gamma_{t+j}. \tag{6.13}$$

[250] See Bohn 1991, Bartolini and Cottarelli 1994, Bohn 1995 as well as Blanchard and Weil 2001 for the TVC/NPG under uncertainty.

Beyond the formulation of future values in expected value terms, uncertainty implies the existence of contingent liabilities, which are introduced into the technical framework in the following.[251]

Contingent Liabilities in the Present-Value Budget Constraint

The government budget may be subject to various contingent explicit and implicit liabilities that were addressed in the previous section. To keep the technical analysis tractable, a "representative" contingent explicit and implicit liability is modeled, which are assumed to enter the analysis in terms of their expected value.[252] In case of budgeting contingent liabilities according to the expected value, two properties of the contingent liability are relevant, namely *(i)* its value and *(ii)* its probability of occurrence.

The value of the liability is denoted by c^e_{t+j} in case of the contingent explicit liability and c^i_{t+j} for the contingent implicit liability. The explicit liability is contractually agreed and hence its value is assumed to be known. For the implicit liability, no face value is available such that the value is itself subject to uncertainty.[253]

The probability of occurrence is characterized for both the explicit (e) and implicit (i) contingent liability by p^m with $m \in \{e, i\}$. It can generally be distributed according to any discrete probability distribution.[254] The literature often assumes that the probability of occurrence of contingent liabilities is distributed according to a Poisson process of parameter λ (see Haight 1967, Panjer and Willmot 1992, Cohen 2002, Klugman et al. 2012). For instance, the probability of occurrence of e.g. a government guarantee or a low-probability high-impact event is assumed to follow a Poisson process in insurance economics (see Panjer and Willmot 1992, Cohen 2002, Nguyen 2007, Cummins and Mahul 2009). The Poisson distribution is a discrete distribution with the probability of occurrence being given by the density function $p^m_\lambda(n) = \frac{\lambda^n}{n!} \cdot e^{-\lambda}$ for $n \in \{1, 2, ...\}$ where λ is the expected frequency of the event triggering the contingent liability and n the frequency of triggering events within a given time horizon. Figure 6.2 gives the probability distribution according to the Poisson process for different values of λ. The frequency n is given on the horizontal axis and the corresponding probability of occurrence on the vertical axis. The right panel indicates that for sufficiently large values of λ, the Poisson distribution is approximated by a normal distribution. By contrast, the other panels suggest that small values of λ generate probability distributions that are suitable for describing the probability of occurrence of less frequent contingent explicit and implicit liabilities.

[251] Moreover, uncertainty would give rise to implicit debt, which is uncertain in terms of the value of the liability. Nonetheless, implicit debt is neglected in the following for convenience.

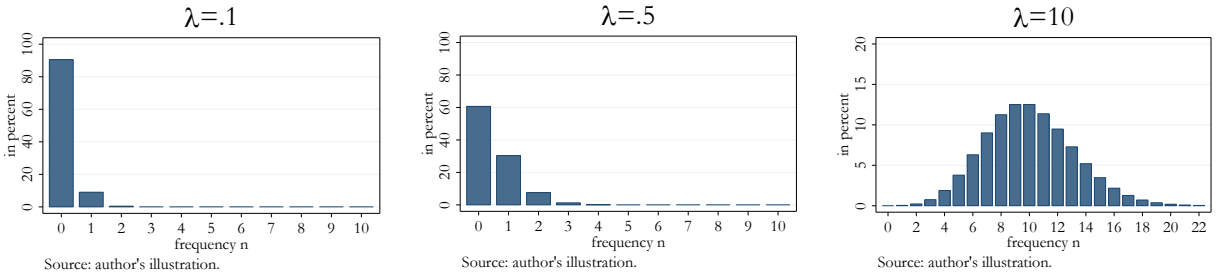
[252] See Cohen 2002 for an analysis arguing that expected costs are not the right measure for budgeting contingent liabilities if the time horizon over which the liability is expected to mature is very short or discounting is very low.

[253] The analysis could be enriched by taking into account this additional layer of uncertainty. The focus is placed upon uncertainty with respect to maturity in the following for the sake of clarity.

[254] See e.g. Ross 2010 and Klugman et al. 2012 for overviews of discrete probability distributions.

Figure 6.2: Probability distributions according to Poisson process

The figure depicts the probability distribution according to the Poisson process for different values of λ. Although the Poisson distribution is approximated by a normal distribution for sufficiently large values of λ (right panel), small values of λ generate distributions that are suitable for describing the probability of occurrence of less frequent contingent government liabilities.



Hence, the probability of occurrence of both types of contingent liabilities is assumed to be described by a Poisson process in the following, i.e. $p^m_\lambda \sim Po(\lambda)$. Therefore, the expected value of the explicit and implicit liability, respectively, in period $t+j$ is given by

$$\mathbb{E}[c^m_{t+j}] = \begin{cases} c^m_{t+j} & \text{with} \quad p^m_{t+j,\lambda}; \\ 0 & \text{with} \quad 1 - p^m_{t+j,\lambda}, \end{cases} \tag{6.14}$$

such that the expected value of the liability is either c^e_{t+j} and c^i_{t+j}, respectively, with probability $p^e_{t+j,\lambda}$ and $p^i_{t+j,\lambda}$, respectively, or zero otherwise.

When taking both representative contingent liabilities into account, the government budget identity in period $t+1$ reads as

$$\mathbb{E}_t[d_{t+1}] = \frac{1+\mathbb{E}_t[r_{t+1}]}{1+\mathbb{E}_t[g_{t+1}]} d_t + \underbrace{p^e_{t+1,\lambda} c^e_{t+1}}_{\mathbb{E}_t[c^e_{t+1}]} + \underbrace{p^i_{t+1,\lambda} c^i_{t+1}}_{\mathbb{E}_t[c^i_{t+1}]} - \mathbb{E}_t[pb_{t+1}] - \mathbb{E}_t[\gamma_{t+1}]. \tag{6.15}$$

Formulating the present-value budget identity analogous to above and imposing the TVC gives the *extended* stochastic PVBC, which represents the comprehensive constraint on the government budget as it incorporates (both explicit and implicit) contingent liabilities together with non-contingent explicit liabilities. It is given by

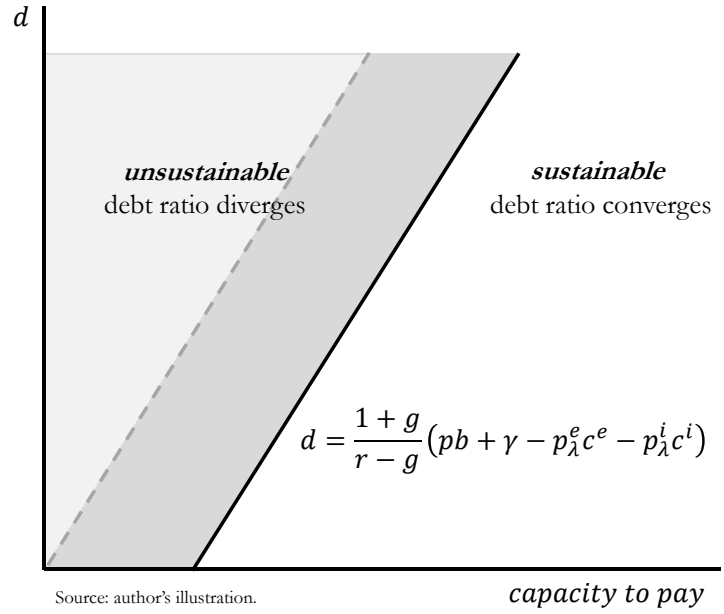
$$\begin{aligned} d_t = &\lim_{j\to\infty} \mathbb{E}_t \sum_{j=0}^{\infty} \prod_{k=1}^{j} \left(\frac{1+r_{t+k}}{1+g_{t+k}}\right)^{-1} pb_{t+j} + \lim_{j\to\infty} \mathbb{E}_t \sum_{j=0}^{\infty} \prod_{k=1}^{j} \left(\frac{1+r_{t+k}}{1+g_{t+k}}\right)^{-1} \gamma_{t+j} \\ &- \lim_{j\to\infty} \sum_{j=0}^{\infty} \prod_{k=1}^{j} \left(\frac{1+r_{t+k}}{1+g_{t+k}}\right)^{-1} p^e_{t+j,\lambda} c^e_{t+j} - \lim_{j\to\infty} \sum_{j=0}^{\infty} \prod_{k=1}^{j} \left(\frac{1+r_{t+k}}{1+g_{t+k}}\right)^{-1} p^i_{t+j,\lambda} c^i_{t+j}. \end{aligned} \tag{6.16}$$

Evaluation of Fiscal Sustainability under Uncertainty

Equation (6.16) as the extended stochastic PVBC serves as the benchmark for evaluating fiscal sustainability under uncertainty. Analogous to the approach under certainty, fiscal sustainability is evaluated for an economy in a (stochastic) steady state. This simplifies Equation (6.16) and fiscal policy is considered sustainable if $d \leq \frac{1+g}{r-g}\left(\mathbb{E}[pb] + \mathbb{E}[\gamma] - p^e_\lambda c^e - p^i_\lambda c^i\right)$. It is assumed in the

Figure 6.3: Fiscal sustainability and debt dynamics under uncertainty

The figure is the analogue to Figure 6.1 and shows that the fiscal sustainability frontier is shifted to the right under uncertainty, meaning that uncertainty restricts fiscal policy. Fiscal policy stances that are deemed unsustainable under uncertainty yet sustainable under certainty are indicated by the dark-gray area. Stances deemed unsustainable under both certainty and uncertainty are reflected in light-gray.



Source: author's illustration.

remainder of this chapter that the primary balance and the transfer from the central bank are at the government's discretion such that there is no uncertainty related to these two budgetary items.[255] Technically, this implies that $\mathbb{E}[pb] = pb$ and $\mathbb{E}[\gamma] = \gamma$ and fiscal policy is deemed sustainable if

$$d \leq \frac{1+g}{r-g}\left(pb + \gamma - p_\lambda^e c^e - p_\lambda^i c^i\right). \tag{6.17}$$

Interpreting again the term in brackets in Condition (6.17) as the government's capacity to pay (see above) shows that this capacity is constrained under uncertainty compared to the situation under certainty owing to the potential occurrence of contingent liabilities. This effect on the capacity to pay and debt dynamics is depicted in Figure 6.3, which is the analogue to Figure 6.1 under uncertainty. The recognition of contingent liabilities shifts the fiscal sustainability frontier determined by Condition (6.17) to the right. The fiscal sustainability frontier under certainty is represented by the dashed line and that under uncertainty by the solid line. Owing to this shift, more fiscal policy stances are deemed unsustainable. Fiscal policy stances that are deemed unsustainable under uncertainty yet sustainable under certainty are indicated by the dark-gray area. Stances deemed unsustainable under both certainty and uncertainty are reflected in light-gray. Therefore, the consideration of uncertainty in fiscal sustainability analysis restricts fiscal policy if sustainable fiscal policy is required.

[255] This assumption is relaxed in Chapter 7.

Under the assumption of a rational government, i.e. choosing the smallest sustainable primary balance such that Condition (6.17) holds with equality, the sustainable primary balance pb^{**} under uncertainty is given by

$$pb^{**} = \frac{r-g}{1+g}d - \gamma + p_\lambda^e c^e + p_\lambda^i c^i = pb^* + p_\lambda^e c^e + p_\lambda^i c^i. \tag{6.18}$$

It is straightforward that $pb^{**} > pb^*$ for any positive probability that contingent liabilities mature such that the necessary primary balance ensuring sustainability is strictly larger under uncertainty than under certainty.

6.5 Overview of the Fiscal Implications of Eurosystem Collateral Criteria

The remainder of this chapter provides an overview of fiscal implications of central bank collateral criteria. These implications are important as amendments to collateral criteria give rise to new government liabilities and induce dynamics in the government liability matrix (Table 6.2), i.e. movements and transitions of liabilities. Three fiscal implications of collateral criteria are briefly reviewed hereafter and thoroughly investigated in Chapters 7 and 8: first, the relationship between collateral criteria and government debt as a non-contingent explicit liability is considered; second, the importance of collateral criteria for potential central bank recapitalization (contingent implicit liability) is examined; and third, it is summarized how collateral criteria shape government incentives to give explicit guarantees (contingent explicit liability).

6.5.1 Collateral Criteria and Government Debt

Collateral criteria bear fiscal implications as they affect the issuance of government bonds, i.e. the assumption of non-contingent explicit liabilities. Usually, government bonds have been considered risk-free and hence as a prototype of collateral as default and liquidity risk was deemed absent. Credit ratings of several governments depreciated during the sovereign debt crisis, even below the minimum credit rating of the Eurosystem in some cases. Consequently, the Eurosystem suspended the minimum credit rating for several countries (see Section 3.2.2) to deem eligible bonds issued by governments of these countries. Relaxed collateral criteria facilitate government indebtedness by lowering the cost of bond issuance in three ways.[256]

First, extended collateral eligibility gives (government) bond holders additional potential utilization (despite holding the bond to maturity) such that eligible assets are usually traded at an eligibility premium (Bindseil and Papadia 2006, Rule 2012, Bindseil 2014 and BIS 2015). Therefore, eligibility implies higher bond prices and lower interest rates, which facilitates government bonds issuance.

Second, when government bonds are pledged as collateral with the Eurosystem, the issuing government de facto pays a fraction of interest to itself in case of counterparty default owing to

[256] Moreover, this gives rise to the crowding-out of private investment as banks would funnel larger amounts of liquidity towards the government rather than profitable investments outside the government sector.

the distribution of interest income in the Eurosystem. This lowers the expected cost of bond issuance and facilitates government indebtedness.

Third, the relaxation of collateral criteria enhances the liquidity of counterparties that can be used to acquire additional government bonds, which can subsequently again be pledged as collateral.[257] This process is self-sustaining and fosters government indebtedness as long as government bonds are pledgeable with the central bank. In this case, the government would benefit from an alleviating effect on the interest rate that it would have to pay on its debt as demand for government bonds would increase. Banks tend to disproportionately expose themselves to government bonds irrespective of central bank collateral criteria. This exposure largely comprises government bonds of the banks' home country, a phenomenon, referred to as home bias in government debt.[258] This home bias is reported to have intensified in the Eurozone since the financial crisis. Arslanalp and Tsuda 2014 document that the fraction of the stock of Eurozone government bonds that banks held from their own government increased on average from 57% in 2007 to 69% in 2011. In Greece, Italy and Spain, it was even close to 100% (see also Coeurdacier and Rey 2013).[259] Anecdotal evidence for the period of the three-year LTROs launched by the Eurosystem reveals that Spanish banks used additional liquidity to acquire additional government bonds to the amount of EUR 85 bn during this period (Sinn 2015a). However, this behavior appears to contradict standard finance theory, which would suggest that banks holding a large stock of domestic government bonds strive to invest in assets with uncorrelated risk to diversify their portfolio. Observable intensification in exposure to domestic government debt can be explained by the following reasons.

Battistini et al. 2013, 2014, Acharya and Steffen 2015 as well as Drechsler et al. 2015 address risk shifting to explain the increase in government bond holdings. Risk shifting, i.e. the externalization of risk, in the banking sector can be referred to three reasons. First, limited liability may induce undercapitalized banks to invest in risky assets. If liability is limited and the downside risk of failing to redeem liabilities is low, banks are incentivized to take excessive risk as they win if the gamble succeeds while their creditors lose otherwise. Sinn 1980, 1983 refers to this phenomenon as the BLOOS rule, alluding to the term "you can't get blood out of a stone" (Sinn 1983, p. 163).[260] Second, the study by Diamond and Rajan 2011 advances the hypothesis that undercapitalized banks allocate investment to illiquid assets such as risky government bonds, given that the state of the world in which the bonds default coincides with the state in which banks themselves default. Hence, portfolio concentration would be rationale as the entire risk is with a state of the world that would be catastrophic regardless. Finally, banks may engage in risk shifting by increasing their stock of risky (domestic) government debt with the endeavor to remain or become systemically important. The government's inability to credibly commit

[257] On the increased importance of government debt as collateral for refinancing (Asonuma et al. 2015) in the market, see Bolton and Jeanne 2011 and from the central bank, see Chapters 3 and 5.

[258] The tendency of investors to predominantly invest in their home country was first documented by French and Poterba 1991 as well as Tesar and Werner 1995 for equities. See e.g. Acharya et al. 2012, 2014b for the home bias in government debt.

[259] Repatriation of government bond holdings is confirmed by Merler and Pisani-Ferry 2012, Andritzky 2012, Levy and Levy 2014, van Riet 2014 as well as Acharya and Steffen 2015. According to Andritzky 2012, Haas and van Horen 2012 as well as Giannetti and Laeven 2012, repatriation in investment is typical pattern in the aftermath of crisis.

[260] See Stiglitz and Weiss 1981 for the phenomenon in a credit market equilibrium context. Others termed it a "gamble for resurrection", see Dewatripont and Tirole 1993, 1994 as well as Sinn 2008.

not to bail out systemically important banks incentivizes banks to excessively and collectively invest in assets that decline during crisis, such as government debt (Acharya and Yorulmazer 2007, Farhi and Tirole 2012, 2014 as well as Gennaioli et al. 2014). Owing to excessive and collective investment, banks maximize the value of the implicit government guarantee. Hence, risk shifting can explain that (undercapitalized) banks scale up holdings of domestic government debt.

Moreover, the hypothesis of moral suasion by the government is put forward to explain portfolio concentration to government debt (e.g. Acharya and Steffen 2015). Accordingly, governments of crisis-stricken countries appeal to domestic banks to increase the absorption of their debt. Marco and Macchiavelli 2014 provide a systematic analysis of moral suasion by governments in recent years, documenting the extent of moral suasion and showing that during the European sovereign debt crisis and upon receiving government support banks significantly increased exposure to domestic government debt only if they had strong political affiliations.[261] This effect appears to be twice as large for banks located in the European periphery. According to Buiter and Rahbari 2012b, many banks were subject to moral suasion by governments to draw credit from the Eurosystem and park the funds in sovereign debt. Battistini et al. 2013, 2014 claim that several national supervisors temporarily promoted a home bias in bank exposure.

Finally, Portes et al. 2001 argue that it is principally advantageous to hold government bonds as they respond less to information frictions than corporate bonds or equity. Arslanalp and Tsuda 2014 quote general factors such as the global recession and new financial regulation in explaining the intensification of domestic government bond holdings after the financial crisis. Weak economic growth in the aftermath of the financial crisis reduced demand for bank loans, prompting banks to increase government bond holdings. Moreover, banks likely intensify government bond holdings to meet new regulation such as Basel III, which demands stricter capital and liquidity standards (ibid.). In addition, financial regulation in place assigning a zero-risk weight to government bonds induces undercapitalized banks to invest in additional government bonds to make use of regulatory arbitrage.

6.5.2 Collateral Criteria and Central Bank Finances

Collateral criteria bear fiscal implications as they are crucial for central bank finances, which are intertwined with the government budget (see Chapter 7). Relaxed collateral criteria may be detrimental to central bank finances owing to three effects. While the first effect is general, the others are specifically related to the Eurosystem. First, central banks predominantly realize income from accumulating interest-bearing assets, which they receive in exchange for self-created money. When collateral criteria are strict, the flow of interest income is steady and safe. Section 7.3.1 shows that when collateral criteria are relaxed, central bank interest income becomes vulnerable. Pledged assets that the central bank would have to liquidate in case of

[261] The authors measure political affiliation as the total percentage of shares held by the government or by political foundations prior to the crisis. Moral suasion of the banking sector by governments is not restricted to the recent past but originates from the close relation between governments and banks. See Buck 2013 for the historical perspective.

counterparty default bear a higher risk of default and are less liquid when collateral criteria are lax. Consequently, the flow of interest income may become less reliable, which can put central bank finances at risk. Second, Section 7.3.2 argues that central bank income in the Eurozone is particularly put at risk by relaxed collateral criteria and the provision of ELA. ELA is provided by NCBs on their own account to solvent banks that lack collateral complying with the (relaxed) uniform Eurosystem collateral criteria. Hence, any relaxation of uniform collateral criteria implicitly lowers collateral criteria applied in ELA. This puts finances of the responsible NCB at risk. Likewise, ELA puts at risk finances of all other NCBs as the responsible NCB is de jure liable for all losses from ELA while liability is de facto limited. Therefore, ELA losses would be shared among NCBs if they exceeded the financial means available to the responsible NCB. Finally, finances of NCBs in the Eurosystem may come under distress owing to intra-Eurosystem imbalances (Section 7.3.3). The relaxation of collateral criteria has resulted in the accumulation of huge claims and liabilities of NCBs towards the ECB. If an NCB fails to settle its liability with the ECB, all NCBs share the write-off losses of the ECB.

Distressed central bank finances may raise the issue of central bank recapitalization ("bailout"), which can take three forms (Section 7.4): first, the central bank can retain part of its profit to bolster financial strength ("internal recapitalization"); second, the central bank can call the government for capital injection ("external recapitalization"); and finally, a third (but government-related) party may divert distress from the central bank balance sheet ("circumvented recapitalization"). Irrespective of the peculiarities of recapitalization, the government bears the contingent implicit liability of central bank bailout, which would adversely affect its fiscal position if it matured as the government would have to divert existing financial means or issue new debt. In the latter case, the contingent implicit liability would transform into a non-contingent explicit liability. Section 7.5 elaborates on the fiscally desired level of collateral criteria, which is the outcome from trading off the cost and benefits from amending collateral criteria from a fiscal perspective. It shows that while the fiscally desired level of collateral criteria is unique in a one-country one-central bank setting, divergent optimal levels can emerge in a multi-country one-central bank setting. It is shown that divergent fiscally desired levels of collateral criteria give rise to cross-country fiscal implications, depending on the uniform level of collateral criteria that the central bank implements. Therefore, it is argued that the relaxation of collateral criteria by the Eurosystem may have resulted in a transfer of fiscal sustainability across countries as collateral criteria are too strict for some countries yet too lax for others.

6.5.3 Collateral Criteria and Government Guarantees

Finally, Chapter 8 shows that collateral criteria shape government incentives to assume contingent explicit liabilities in terms of explicit individual guarantees and insurance schemes to the banking sector (see Table 6.2). Section 3.2.2 analyzed that the Eurosystem relaxed collateral criteria for government-guaranteed assets after the onset of the financial crisis. This endowed governments the discretion to free up collateral as explicit government guarantees may have three effects on assets: first, the guarantee can be basal for eligibility, e.g. in case of own-use uncovered bank bonds; second, the guarantee would augment the collateral value of an eligi-

ble asset if it improved the credit assessment deemed decisive for haircut determination; and third, the guarantee augments the collateral value by increasing the market value of the asset. If governments make use of this discretion, collateral criteria bear fiscal implications as they imply dynamics in the government liability matrix as governments assume additional contingent explicit liabilities or make existing implicit guarantees explicit. Chapter 8 indicates that governments of several crisis-stricken countries have made use of their discretion in recent years. They have initiated new and extended existing explicit guarantee schemes as well as granting individual explicit guarantees to facilitate the refinancing of local banks with the Eurosystem. This finding motivates a novel rationale for governments to give guarantees to the banking sector beyond the common rationale, i.e. preventing panic-driven runs on solvent yet illiquid financial institutions (Diamond and Dybvig 1983). The novel rationale explains government incentive to give guarantees based on their discretion to provide collateral to banks, which is inherent in the central bank collateral framework. Moreover, the novel rationale can contribute to explain the development of explicit government guarantees to eligible marketable assets observable in the Eurozone.

7

Fiscal Implication from Collateral Criteria and Central Bank Finances

This chapter elaborates on the fiscal implication of collateral criteria that evolves from the close relation between collateral criteria, central bank finances and the government budget. The relaxation of collateral criteria can give rise to central bank financial straits, prompting the government to provide financial support to the central bank ("central bank bailout"). The chapter argues that collateral criteria have a bearing on central bank finances in three ways, the first of which is general, while the second and third are specific to the Eurosystem. First, amendments to collateral criteria alter the expected value of central bank income from money creation. Consequently, the expected income from money creation to the Eurosystem has deteriorated over recent years owing to relaxed collateral criteria. This effect has been reinforced by the adverse selection of collateral. Second, the provision of Emergency Liquidity Assistance (ELA) puts central bank income in the Eurosystem further at risk as it is granted against collateral of lower quality than stipulated by the collateral framework. Third, the accumulation of intra-Eurosystem balances was facilitated by relaxed collateral criteria, thus jeopardizing central bank finances in the Eurosystem. Amendments to collateral criteria hence affect central bank finances and the likelihood of central bank bailout. The fiscally desired level of collateral criteria balances the costs and benefits to the Treasury from amending collateral criteria. It is shown that uniform collateral criteria bear fiscal implications in a stylized form of the Eurozone when Treasuries prefer distinct levels of collateral criteria. Depending on their level, uniform collateral criteria give rise to risk-sharing and the transfer of fiscal sustainability across countries. The chapter is structured as follows. Section 7.1 emphasizes the relevance of central bank finances and Section 7.2 presents stylized facts on central bank finances in the Eurosystem. Section 7.3 elaborates on the importance of collateral criteria for central bank finances in due consideration of developments in the Eurosystem. Section 7.4 argues that financially-stricken central banks may call the government for recapitalization. Finally, Section 7.5 presents a model to characterize the fiscally desired level of collateral criteria and elaborates on the fiscal implications of collateral criteria via their effect on central bank finances.

7.1 Relevance of Central Bank Finances

While the issue of central bank finances has long been confined to developing countries, it has been placed on the agenda in advanced economies in the recent past as central banks took more active policies, thus rendering their finances more vulnerable.[262] For instance, the ECB claimed additional capital from the NCBs to the amount of EUR 5 bn in December 2010, accounting inter alia for growing credit risk.[263] Hence, capital of the ECB surged from EUR 5.76 bn to EUR 10.76 bn. This anecdotal evidence suggests that central bank finances are a topical issue, which is emphasized by Lönnberg and Stella 2008, Schobert 2008, as well as Lehmbecker 2009.[264] Lönnberg and Stella 2008 present evidence on fifteen Central and South American central banks that experienced losses for five or more years between 1987 and 2005. Schobert 2008 documents that 43 out of 108 central banks bore losses from 1984 to 2005. Lehmbecker 2009 reports that half of a sample of 62 central banks recorded losses at least in one year between 1990 and 2003.

The major reason why central bank finances experienced a surge in attention is the non-standard measures by which central banks all over the world intervened as lender of last resort (LOLR) to unprecedented extent. LOLR-lending was identified as a major cause of central bank financial straits (Hawkins 2003 and Cukierman 2011) as it is associated with greater risk to central banks' balance sheets.[265] This concern was particularly raised with respect to NCBs of the Eurosystem, which were increasingly exposed to risk from purchases of and lending against lower quality assets (e.g. Sibert 2009, Buiter and Rahbari 2012b as well as Sinn 2012, 2014b).

Why do central banks hold capital? The primary reason for any bank is to absorb potential losses in adverse states of the world, which would otherwise imply negative capital and balance-sheet insolvency.[266,267] A commercial bank deemed balance-sheet insolvent is forced to quit operating and is liquidated. By contrast, a balance-sheet insolvent central bank cannot be forced to quit operating as it is typically excluded from company law and, where applicable, it is explicitly protected from bankruptcy or related proceedings (Archer and Moser-Boehm 2013). Hence, a central bank can never be considered balance-sheet insolvent from a legal perspective. In addition, there is also a repeatedly adduced economic reason (e.g. de Grauwe and Ji 2013).[268] The central bank usually possesses the monopoly right to create the economy's legal tender,

[262] Accordingly, literature on central bank finances has been limited yet growing in recent years. See Adler et al. 2012, Archer and Moser-Boehm 2013, as well as Schwarz et al. 2014 for recent contributions.

[263] Furthermore, the recapitalization aimed at enabling the ECB to augment its risk buffer as the provision and reserves are statutorily limited to the level of paid-up capital.

[264] For earlier evidence, see e.g. Leone 1994 for a study providing data on central bank losses for a group of fourteen Latin American countries between 1987 and 1992. The author observes that some countries report fiscal deficits smaller than central bank losses.

[265] Cukierman 2011 e.g. argues that monetary policy actions taken during the crisis increased the risk profile of assets held by the central banks, whereby such policy action might create large capital losses, potentially leading to low or negative levels of capital, including in the longer run.

[266] Moreover, capital may be intended to cover start-up costs (Stella 1997).

[267] "Balance-sheet insolvency" refers to the situation in which a bank holds liabilities in excess of assets. The other concept of bank insolvency is "cash-flow insolvency" (illiquidity), in which the bank is unable to pay obligations as they fall due (Buiter 2008a and Lastra 2011).

[268] It refers to situations in which liabilities are predominately nominally denominated (i.e. not index-linked) or denominated in domestic currency. If denomination is nominal or in foreign currency, a central bank would be increasingly exposed to the threat of cash-flow insolvency.

i.e. money. Money is created at virtually no cost while the central bank receives interest in exchange for it. Buiter 2008a argues that the central bank is not restricted in terms of money creation, thus implying what ibid. terms the "short-term deep pockets" of the central bank, which complement the "long-term deep pockets" of the government (see also Chailloux et al. 2008b). The short-term deep pockets give rise to the central bank franchise value[269], which was claimed to be included as an intangible asset in a comprehensive central bank balance sheet (Buiter 2008a, Buiter and Rahbari 2012a,b).[270] The residual in this comprehensive balance sheet would be central bank net worth, which could substantially differ from central bank capital (residual of the conventional central bank balance sheet). When central bank capital is negative while net worth remains positive, the central bank would be considered balance-sheet insolvent based on its conventional balance sheet but solvent with respect to its comprehensive balance sheet.

While this reasoning sounds appealing as it allows for the power of central banks to generate income by money creation, it is misleading from an accounting perspective.[271] Money creation is neutral from an accounting perspective and no net worth can be created out of the blue (Caruana 2012) as it gives rise to a corresponding accumulation of interest-bearing assets. The stream of interest income that the central bank receives is exactly equal in present-value terms to the value of assets in the balance sheet. Hence, the central bank franchise value is fully matched by the current (reflected in the conventional and comprehensive balance sheet) and future value (reflected only in the comprehensive balance sheet) of base money. Hence, the net worth of the central bank cannot be augmented by accounting wrinkles as future base money also has to be accounted for in the comprehensive balance sheet in terms of an intangible liability.

Beyond accounting subtleties, anecdotal evidence and empirical analyses suggest that central banks care about their financial position and perform monetary policy under due consideration of their finances.[272] For instance, Friedman and Schwartz 1963 claim that balance sheet concerns were a factor crucial in preventing the Federal Reserve from an aggressive expansionary response to the Great Depression in the 1920s. More recently, Cargill 2005, Benecká et al. 2012 and Nyborg 2015 requote policy-makers of the Bank of Japan, the Swiss National Bank and the Dutch Central Bank, expressing concern about the potential deterioration of finances induced by non-standard monetary policy measures. The ECB itself states that "an NCB should always be sufficiently capitalized. In particular, any situation should be avoided whereby for a prolonged period of time an NCB's net equity is below the level of its statutory capital or

[269] See Fry 1993, Stella 1997, Hawkins 2003, Pringle 2003a,b on the franchise value of central banks.

[270] In addition to the franchise value, measured as the present value of income from money creation, intangible liabilities such as the present value of the cost running the central bank and the present value of payments to the government may be considered in the comprehensive balance sheet.

[271] See also Lehmbecker 2009 for a critical appraisal, where it is argued that reliance on the franchise value of the central bank could be misleading as it is impossible to assess.

[272] Bindseil et al. 2004 review the literature, finding that sufficient capital is regarded as a crucial prerequisite for a central bank's ability to achieve monetary stability. More recent surveys are provided by Adler et al. 2012 as well as Archer and Moser-Boehm 2013. Sims 2004 provides a theoretical approach showing that a central bank concerned about its independence could refrain from implementing expansive monetary policy owing to risk to its balance sheet. Likewise, Jeanne and Svensson 2007 argue that central banks care about their financial position and pursue suboptimal policies to minimize the risk of losing independence, which could be impaired by financial weakness. Sinclair and Milton 2011 claim that central bank capital is relevant as potential fiscal back-up is both costly and uncertain.

is even negative. [...] Therefore, the event of an NCB's net equity becoming less than its statutory capital or even negative would require that the respective Member State provides the NCB with an appropriate amount of capital [...] within a reasonable period of time" (ECB 2012a, pp. 25-6). Moreover, empirical analyses explore the effects of central bank finances on monetary policy outcomes such as inflation. Ize 2006 divides a sample of 87 central banks into subsamples with either positive or negative structural profits and finds average inflation in the former subsample to be 3.5% but considerably higher in the latter (9.5%). Stella 2003 applies an akin approach and produces similar results for a different sample and different years. Stella 2011 investigates an artificial indicator for central bank financial strength for a wider sample of central banks in a different set of years, confirming that central banks with weak finances tend to have higher inflation outcomes. However, these studies fail to control for the presence of other factors that may affect policy outcomes. Taking an econometric approach to control for such factors, Klüh and Stella 2008 find a negative relationship between central bank financial strength and inflation outcomes, which is robust to the choice of alternative country samples, control variables, estimation strategies and concepts of central bank financial strength. Adler et al. 2012 have recently investigated the effects of central bank finances on deviations of the interest rate from its "optimal" level (in the spirit of Taylor), finding statistically significant effects.

Various causes for deterioration in central bank finances have been revealed in the past,[273] such as *(i)* periods of credibility build-up (Hawkins 2003, Cukierman 2011), *(ii)* interventions to stabilize the exchange rate (Dalton and Dziobek 2005, Cukierman 2011), *(iii)* quasi-fiscal operations (Stella 1997, Hawkins 2003, Martínez-Resano 2004, Gros 2004, Stella 2008, Buiter and Rahbari 2012a) and *(iv)* deterioration in profitability (Dalton and Dziobek 2005, Papi 2011).[274] It is argued in the following that recent non-standard monetary policy measures of the Eurosystem put at risk central bank finances owing to a combination of *(iii)* and *(iv)*. Quasi-fiscal activities often take the form of central bank support to the financial sector in terms of subsidized loans and the purchase of overvalued or non-performing assets.[275] This support often proves to have detrimental effects on central bank profitability (Hawkins 2003, Stella 1997, Cukierman 2011), particularly when performed at low interest rates and against potentially inadequate collateral (Ernhagen et al. 2002).

7.2 Stylized Facts on Central Bank Finances in the Eurosystem

This section elaborates three stylized facts on central bank finances in the Eurosystem that were affected by non-standard monetary policy measures performed by the Eurosystem since the financial crisis.[276]

[273] See Leone 1994, Ernhagen et al. 2002, Dalton and Dziobek 2005 as well as Papi 2011 for overviews.

[274] Furthermore, Darbyshire 2011 suggests that the implementation of more rigorous central bank accounting standards has amplified central bank financial straits.

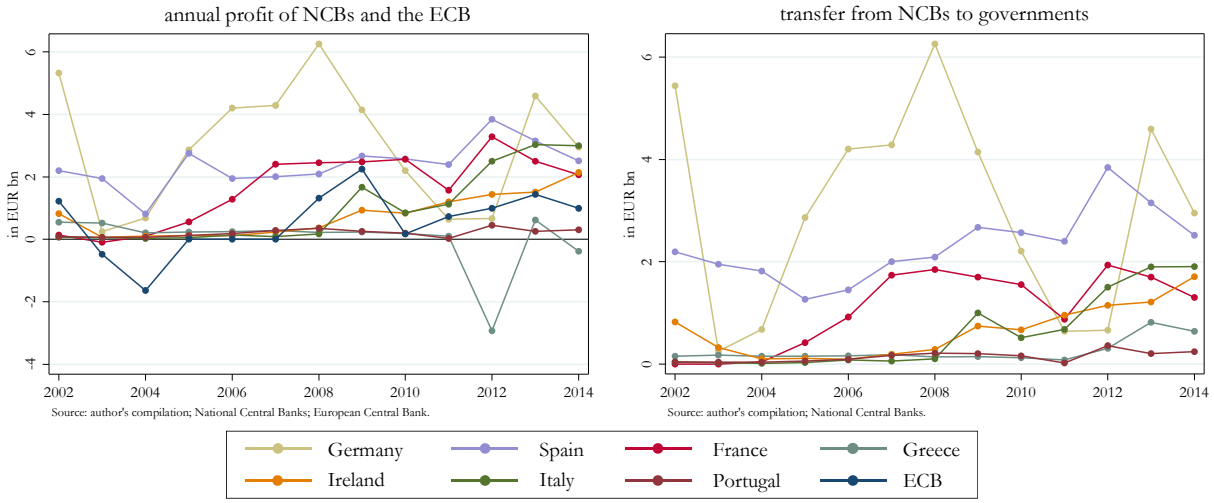
[275] Gros 2004 investigates the effect of central bank quasi-fiscal activities on its inflation performance and finds a statistically significant correlation between the leanness of the central bank balance sheet and average inflation for a sample of European central banks between 1967 to 1990; namely, the less quasi-fiscal activities that a central bank had to perform, the better its inflation performance.

[276] See e.g. Cour-Thimann and Winkler 2013, Claeys 2014, Domanski et al. 2014 as well as Chapter 2 for the non-standard measures and Archer and Moser-Boehm 2013 for effects on central bank financial strength.

Stylized Fact 7.1: Sustained profitability and transfers. The left panel of Figure 7.1 indicates that selected NCBs have remained profitable over recent years, with the exception of the Bank of Greece, which showed losses in 2012 and 2014. Prior to the financial crisis, the ECB showed losses in 2003 and 2004, as well as zero-profits from 2005 to 2007, although profits increased during the financial crisis in 2008 and 2009. By contrast, profits of the Deutsche Bundesbank considerably declined between 2008 and 2012, while the Banca d'Italia increased and sustained high profits as of 2008. Accordingly, transfers to governments (right panel) remained high and even increased for most NCBs, while the Deutsche Bundesbank had to considerably reduce its transfers after the financial crisis between 2008 and 2012 owing to low profits.

Figure 7.1: Annual profits of selected NCBs and the ECB as well as transfers to governments

The figure shows the development of central bank annual profits and transfers to governments. The left panel indicates that NCBs remained profitable over recent years, with the exception of the Bank of Greece, which showed losses in 2012 and 2014. Accordingly, transfers to governments (right panel) remained high or even increased for most NCB, while the Deutsche Bundesbank had to reduce its transfers after the financial crisis.



Stylized Fact 7.2: Profitability was sustained owing to riskier monetary policy. Sustained profitability can be mainly ascribed to the Eurosystem having engaged as LOLR since the onset of the financial crisis by substantially increasing liquidity provision (Chapter 2). Ize and Oulidi 2009 find that more active central banks (or central banks operating in more turbulent macroeconomic environments) become more exposed to extraordinary profits. This suggests balance sheet volatility as a good predictor of central bank profitability. In normal times, central banks strive for a lean balance sheet, characterized by interest-free banknotes representing the majority of liabilities and hence of the balance sheet total. In times of crisis, central banks tend to become more active and perform non-standard measures, which implies the accumulation of liabilities other than banknotes. The balance sheet leanness indicator (BSLI) provides information on balance sheet volatility and puts the balance sheet total in relation to banknotes in circulation.[277] It is given by

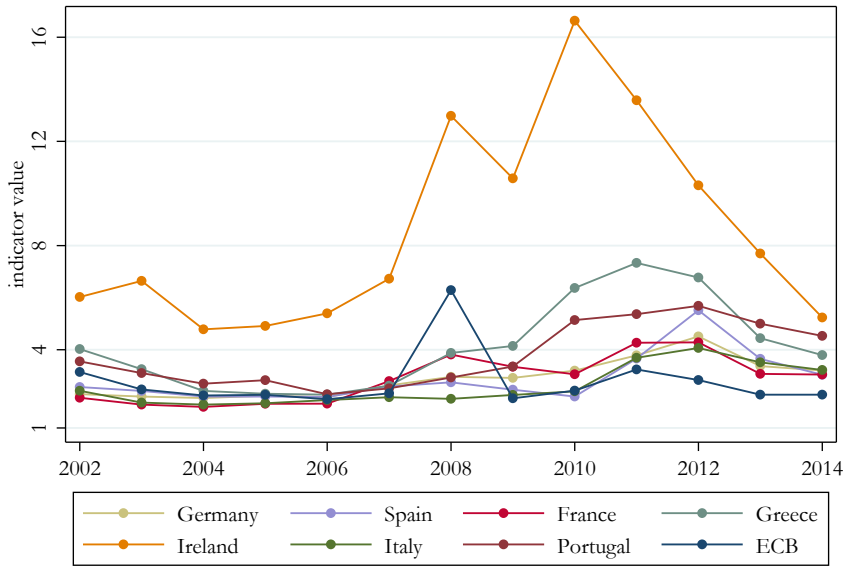
$$\text{BSLI} = \frac{\text{balance sheet total}}{\text{banknotes in circulation}}. \tag{7.1}$$

[277] See e.g. Bindseil 2014 for the BSLI. A similar indicator is applied in Gros 2004, reflecting the ratio of total liabilities over the monetary base.

A BSLI equal to unity indicates a perfectly lean balance sheet, i.e. interest-free banknotes are the sole liability of the central bank. Bindseil 2014 argues that such a balance sheet suggests that a central bank is focused on its core mandate of price stability and that financial markets function well because the central bank is neither used as intermediary by the banking system nor is it engaged in special measures, e.g. sterilizing asset purchases. A balance sheet that exceeds unity largely indicates that a central bank is not entirely focused on price stability but engages in non-standard measures. Figure 7.2 illustrates the development of the BSLI for selected NCBs from 2002 to 2014. It reveals a convergence of the BSLI except for the Bank for Ireland prior to the financial crisis towards a BSLI value of 2.4. The BSLI diverged as of 2008 and resumed to converge as of 2013. Crisis-related increases were most prominent for the ECB with a jump in 2008, and for the Bank of Greece as well as the Banco de Portugal, for which the BSLI substantially increased from 2007 to 2012. The BSLI of the Banco de España remained low after the outset of the financial crisis but considerably increased during the sovereign debt crisis as of 2010. The Central Bank of Ireland has the most volatile BSLI: already running at a high level prior to the financial crisis, it considerably increased during the financial crisis and peaked at 16.6 in 2010, before continuously decreasing thereafter. This development indicates that the sustained profitability of NCBs was associated with the extension of the monetary base by extended liquidity provision. While this contributed to preserving central bank sustainability, it makes NCBs and the ECB prone to extraordinary losses. This is emphasized by Ize and Oulidi 2009, who find that more active central banks also become more exposed to extraordinary losses.

Figure 7.2: Balance sheet leanness indicator for selected NCBs

The figure illustrates the development of the BSLI for selected NCBs from 2002 to 2014. It reveals convergence of the BSLI prior to the financial crisis, aside from the Bank for Ireland, which has the most volatile BSLI. The BSLI diverged as of 2008 and resumed to converge as of 2012.



Source: author's calculation; National Central Banks; European Central Bank.

Stylized Fact 7.3: NCBs moderately adapted risk buffer. NCBs responded to the increase in risk exposure by adapting buffers against balance sheet shocks. A risk buffer comprises *(i)* capital and reserves, *(ii)* revaluation accounts and *(iii)* provisions and its development is

revealed in Figure 7.3 for selected NCBs. The development of capital and reserves relative to the balance sheet total is depicted in the upper-left panel, showing that the ratio of capital and reserves remained low or shrunk for most NCBs owing to an expansion in balance sheets. The overall average ratio steadily declined from 4.1% in 2002 to 2.6% in the pre-crisis year of 2007 to 2.1% in 2014. The ratio of capital and reserves of the ECB experienced a drop in 2008 but recovered thereafter. Another component of the risk buffer is revaluation accounts, which are held as protection against changes in asset valuation. Financial means retained for potential revaluation relative to the balance sheet total are displayed in the upper-right panel of Figure 7.3. Large volatility is due to changes in both absolute revaluation accounts and balance sheet sizes. The average ratio increased from 5.9% in 2002 to 6.4% in 2007 to 9.5% in 2014. Remarkably, the Central Bank of Ireland has substantially increased its revaluation accounts since 2012 and the Banca d'Italia accumulated revaluation accounts at a peak of 21.1% of the balance sheet total in 2010, although it sharply decreased thereafter. The bottom-left panel gives the ratio of provisions to the balance sheet total. The average provisions ratio decreased from 4.3% in 2002 to 2.2% in 2008, with the Banca d'Italia and the Banco de Portugal holding above-average relative provisions. The average ratio advanced to 3.3% in 2014 despite the additional risk that central banks have subsequently assumed with the non-standard measures. While relative risk provisions dropped for the Banca d'Italia and the Banco de España, provisions of the Bank of Greece experienced a marked growth.[278] Mandatory "special provisions for monetary policy operations" are included in provisions, given in the bottom-right panel. These provisions were accumulated by NCBs according to capital keys with the ECB to counteract increased counterparty risk in collateralized lending, which culminated in the default of five counterparties in the fall of 2008 (Section 7.3.1.3). This cushion was accumulated in 2008 and steadily decreased thereafter until it was dissolved in 2013.

This section has revealed that while NCBs has remained profitable over recent years, support to the financial system by expanded liquidity provision through non-standard policy measures has been associated with higher risk to their balance sheets. NCBs only moderately adapted risk buffers, which left them prone to the potential effects of adverse shocks to the balance sheet. The next section elaborates on three potential sources of shocks to central bank balance sheets and particularly concerning the importance of collateral criteria in this context.

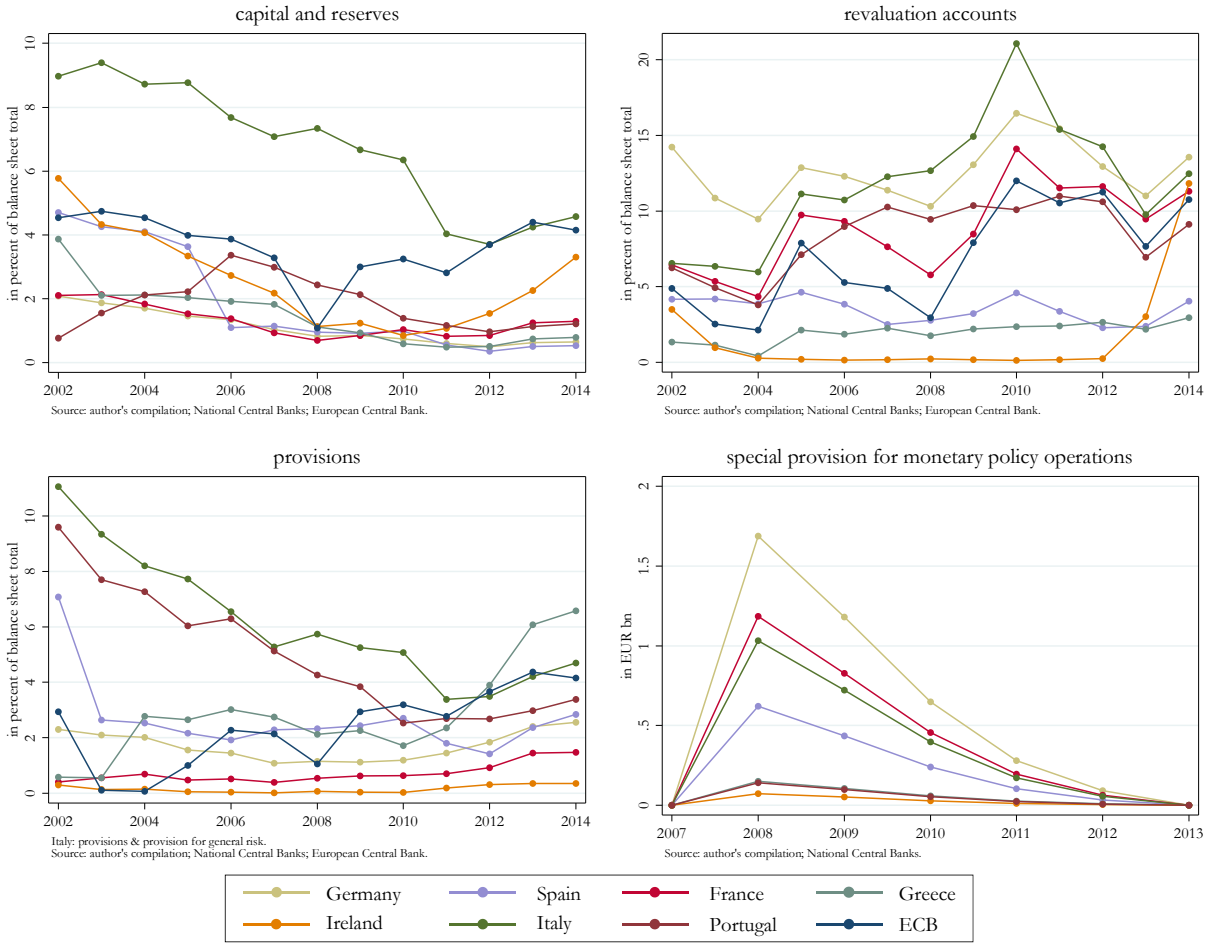
7.3 Collateral Criteria and Central Bank Finances

This section elaborates on the importance of collateral criteria for central bank finances. It argues that collateral criteria are crucial to central bank income from money creation as collateral serves as a risk hedge in case of counterparty default (Section 7.3.1). The relaxation of collateral criteria together with insufficient risk control subsequently puts at risk central bank income from money creation, whereby this effect is amplified in case of the adverse selection of collateral. Moreover, it is addressed that collateral criteria in the Eurosystem and particularly their relaxation were decisive for two developments in the Eurozone, i.e. the provision of ELA (Section 7.3.2) and the

[278] This growth was due to increases in the absolute amount of provisions, which changed from EUR 1.1 bn in 2008 to EUR 6.8 bn in 2014.

Figure 7.3: Risk buffer of selected NCBs and the ECB

The figure details the development of a risk buffer in the Eurosystem from 2002 to 2014, comprising *(i)* capital and reserves, *(ii)* revaluation accounts and *(iii)* provisions. Moreover, the bottom-right panel illustrates "special provisions for monetary policy operations", which were temporarily accumulated in 2008. The overall impression is that the Eurosystem only moderately adapted a risk buffer despite higher risk from non-standard monetary policy measures.



accumulation of intra-Eurosystem imbalances (Section 7.3.3). While the relevance of collateral criteria for income from money creation is general to central banks, the relevance for ELA and intra-Eurosystem imbalances is specific to the Eurosystem.

7.3.1 Collateral Criteria and the Income from Money Creation

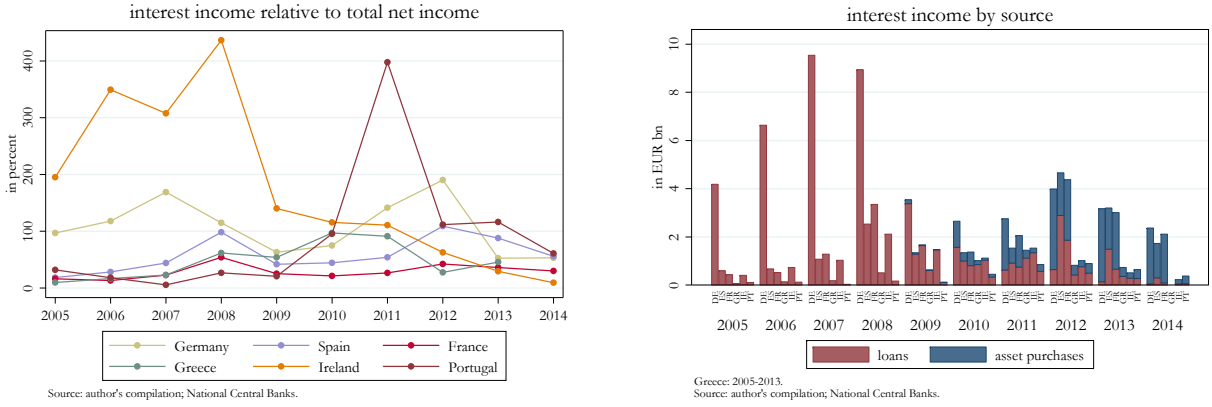
Income that the central bank realizes by using self-created money (base money) for lending or purchases is referred to as "seignorage".[279] While base money is accounted as a liability in the central bank balance sheet, it is not a true liability in the economic sense for two reasons (cf. Lange 1995, Sinn and Feist 1997 as well as de Grauwe and Ji 2013). First, demand for base money increases in a growing economy, such that redemption claims against the central bank

[279] In its historical sense, "seignorage" refers to the income of the "seigneur" who issued money against its face value. For early analyses of seignorage and sources of central bank income, see e.g. Thornton 1802, Bresciani-Turroni 1937 and Cagan 1956.

are unlikely.[280] Second, base money does not give interest to its holder such that it is interest-free to the central bank. Hence, the central bank realizes interest income on the assets that it receives in exchange for base money. Interest income represents a substantial part of central bank income, as Figure 7.4 reveals for selected NCBs. The left panel details interest income from both lending and purchases relative to total net income. It reveals that the importance of interest income differs across NCBs, whereby it grew from 2005 to 2014 for the NCBs of Spain, France, Greece and Portugal yet diminished in Germany and Ireland. The right panel shows absolute interest income from lending and purchases for the NCBs of Germany, Spain, Greece, Ireland and Portugal.[281] It points to the growing importance of interest income from asset purchases and reveals that interest income became volatile as of 2008 despite growth for all NCBs prior to the financial crisis. Since then, three phases can be identified. First, all NCBs aside from the Bank of Greece experienced a contraction in interest income after the onset of the financial crisis (2008-2009). Second, this contraction was compensated during the sovereign debt crisis (2010-2012), predominantly owing to larger interest income from asset purchases. Compensation substantially varied across NCBs, with the NCBs of Spain, France, Greece and Portugal being the main profiteers. Third, interest income deteriorated again as of 2012.

Figure 7.4: Importance of interest income from central bank loans and asset purchases[282]

The figure reveals that interest income represents a substantial part of central bank income for selected NCBs. The left panel details the development of interest income relative to total net income from 2005 to 2014, suggesting that interest income differs in its importance to NCBs. The right panel differentiates between interest income from loans and purchases, suggesting that interest income became more dependent on asset purchases.



The following aims to explain the developments observable in Figure 7.4. It argues that interest income is associated with a larger degree of uncertainty when collateral criteria are relaxed.

[280] A lack of redemption alone does not suffice to disqualify base money from being a true liability because, like a perpetuity, potential interest yields would imply a negative (positive) present value for the debtor (creditor), Lange 1995.

[281] The Banca d'Italia does not publish detailed information on income from asset purchases for monetary policy operations.

7.3.1.1 Measuring Income from Money Creation

No commonly-accepted measure of seignorage exists as the income from money creation. Three measures that have been most prominently proposed are briefly reviewed in the following,[283] i.e. *(i)* opportunity cost seignorage, *(ii)* monetary seignorage and *(iii)* fiscal seignorage.[284] The analysis makes the following simplifications without loss of generality. First, the central bank only receives interest income from loans and purchased assets, which abstracts from e.g. income from other central bank assets such as gold or foreign exchange reserves. Second, costs of money creation like material, production and maintenance expenses are neglected as they are negligible in today's fiat money system. Hence, the concepts presented in the following are defined as gross concepts.[285] Third, minimum reserves that central banks usually require commercial banks to hold are interest-free such that the economic nature of minimum reserves is similar to that of currency and the entire monetary base is not remunerated. Fourth, the central bank distributes its entire earnings to the government and does not retain any interest income.[286]

Opportunity Cost Seignorage The concept of opportunity cost seignorage centers upon the feature of base money being interest-free.[287] The private sector holds base money because it either provides utility or is forced to do so by the central bank in terms of reserve requirements. Irrespective of the motivation, base money is an interest-free asset to the private sector such that seignorage is measured in terms of foregone interest income, i.e. the opportunity cost of holding money, of the private sector.[288] Opportunity cost seignorage δ_{opp} is formalized as

$$\delta_{opp} = \frac{iM_t}{P}, \tag{7.2}$$

with i being the market interest rate, M_t the monetary base in period t and P the time-invariant price level. However, the application of the concept of opportunity cost seignorage causes two problems. On the one hand, opportunity cost seignorage may not equal the actual income from base money creation whenever the structure of the asset portfolio of the central bank differs from that preferred by private investors (Neumann 1992).[289] On the other hand, the time path of the true nominal interest rate i has to be chosen (Sinn and Feist 2000). A reasonable yet error-prone approach would be to determine the weighted average of observable asset returns that meaningfully approximates the true opportunity cost of money holders (Klein and Neumann 1990). In order to avoid these problems, empirical studies have focused on the following concept of seignorage (Fischer 1982 and Mankiw 1987).

[283] See Drazen 1985, King and Plosser 1985, Klein and Neumann 1990, Neumann 1992, Gros 1993, Jordan 1994, Lange 1995, Neumann 1996, Honohan 1996 and Buiter 2007 for further reviews.

[284] A fourth—albeit less frequently applied—approach is to multiply base money by the inflation rate, see e.g Bailey 1956, Friedman 1956 as well as Poterba and Rotemberg 1990.

[285] See e.g. Lange 1995 for net concepts.

[286] This simplification is relaxed in Section 7.4.

[287] See Bailey 1956, Phelps 1973, Auernheimer 1974 and Marty 1978 for standard references. For applications of the concept, see e.g. among others Barro 1982 for the US and Lange 1995 for Germany.

[288] An alternative interpretation is to consider the monetary base as interest-free credit from the private to the public sector. In this case, opportunity cost seignorage gives the real value of per-period saved interest payments by the government (Gros 1989). Both interpretations are only equivalent if opportunity cost of the private and the public sector are equal.

[289] This argument may not hold if opportunity cost seignorage is interpreted as the interest savings for the government from issuing base money, see ibid.

Monetary seignorage The concept of monetary seignorage refers to seignorage as the net change in base money outstanding.[290] Therefore, it measures the actual wealth transfer that the private sector has to make to the public sector to receive base money. Monetary seignorage δ_{mon} is formalized as

$$\delta_{mon} = \frac{M_t - M_{t-1}}{P} = \frac{\Delta M}{P}, \tag{7.3}$$

where ΔM represents the change in base money between periods $t-1$ and t. Monetary seignorage is a flow concept associated with certain shortcomings. For instance, it can only arise if the monetary base is increased, which conflicts with any positive interest income that may accrue even with a constant monetary base from prior base money creation. Moreover, as monetary seignorage considers the creation of base money, it may deviate from interest income that does not accrue before the assets backing the monetary base pay interest.[291]

The flow concept of monetary seignorage and the stock concept of opportunity cost seignorage are interrelated as follows. From an economic perspective, there is little difference between focusing on interest wealth (stock) or interest income (flow) because the accumulated stock of interest-bearing assets equals the present value of interest income. This present value equals today's market value of the assets that generate interest. Therefore, stock and flow approaches are equivalent under the prerequisite that the interest-bearing assets of the central bank are evaluated at their market value.[292] Abstracting from inflation, a one-shot increase in base money today ($t = 0$) is exactly equal to monetary seignorage and induces an infinite interest flow on assets accumulated owing to the additional base money, such that

$$\delta_{mon} = \frac{\Delta M}{P} = \frac{1}{P} \sum_{t=1}^{\infty} \frac{i \Delta M}{(1+\beta)^t} = V(\delta_{opp}), \tag{7.4}$$

where β is the discount rate and $V(\cdot)$ denotes the present value. This infinite interest flow corresponds to the present value of seignorage measured by the opportunity cost concept. The stock concept (opportunity cost concept) of seignorage hence corresponds to the flow concept (monetary seignorage) when the former is measured in present value terms.

Both concepts only implicitly consider the actual source of income from money creation, i.e. the assets backing the monetary base. Hence, both concepts abstract from the actual process of base money creation with the result that they may fail to measure the actual amount of seignorage.[293] Klein and Neumann 1990 coin the term "fiscal seignorage" as an alternative approach to measure seignorage at its actual source.

[290] For monetary seignorage, see Cagan 1956, Marty 1967, Dornbusch 1988, Grilli 1988 and Klein and Neumann 1990. Friedman 1971, Calvo 1978 as well as Fischer et al. 2002 use the concept to determine the income-maximizing inflation tax, where the inflation tax is the reduction in the real value of the monetary base caused by inflation. See also Easterly et al. 1995.

[291] This shortcoming does not apply to opportunity cost seignorage, which is a stock concept and measures seignorage at the time when interest income accrues to the central bank.

[292] Central banks are usually required to comply with international financial reporting standards that account assets according to their market value (mark-to-market accounting), see Hawkins 2003 and Pringle 2003a. The equivalence of stock and flow approaches fails to hold (irrespective of accounting) if some assets of the central bank do not generate income (see Sinn and Feist 1997).

[293] Neumann 1992 assumes this point of criticism and presents an approach that takes into account the structure of assets backing the monetary base. This approach extends monetary seignorage by including the interest income on the assets backing the monetary base, i.e. $\delta_{mon,ext} = \Delta M/P + i(M_t/P)$.

Fiscal seignorage Fiscal seignorage measures the income that the central bank receives from interest-bearing assets backing base money.[294] While Klein and Neumann 1990 consider fiscal seignorage in a sources-and-uses format such that it is determined residually in either monetary or opportunity cost seignorage, Neumann 1992 as well as Lange 1995 take into account the actual source of seignorage, i.e. the assets that the central bank receives in exchange for base money. Under the assumption that base money is solely created by lending to commercial banks, fiscal seignorage can be formalized as

$$\delta_{fisc} = \frac{i_L L_t}{P}, \tag{7.5}$$

where L_t are loans granted to the private sector in period t and i_L is the (uniform) interest rate on these loans.

The concepts of seignorage presented thus far explain shortfalls in seignorage over time only by a decreasing interest rate or monetary base. However, shortfalls may occur for a non-decreasing interest rate or monetary base as the assets backing the monetary base may default. The assets backing the monetary base have been implicitly assumed to be perfectly safe thus far. The negligence of default risks leaves aside valuable insights on sustaining seignorage as an important source of central bank income. An alternative concept of seignorage is developed in the following, aiming to correctly grasp both the actual process of base money creation and the default risk of assets backing the monetary base. This alternative concept is closely related to fiscal seignorage and it explicitly considers the asset side of the central bank balance sheet.

7.3.1.2 Asset-Side Approach to Income from Money Creation

This approach focuses on the asset side of the central bank balance sheet as the assets backing the monetary base are the source of income from money creation. By lending or selling base money to the private sector, the central bank accumulates assets in its balance sheet, as stylized in Figure 7.5.[295] Accordingly, the process of base money creation is accompanied by the accumulation of interest-bearing assets on the left-hand side of the balance sheet and a non-interest-bearing liability on the right-hand side. Assets that the central bank accumulates are loans to the private sector (L) as well as public and private securities (A) purchased in the market. The total value of assets is equal to the stock of base money M (comprising banknotes and reserves of commercial banks held with the central bank).

Despite serving as an ideal starting point for elaborating the alternative concept of seignorage, accounting principles and the stylized balance sheet are not well suited to describing the phenomenon of creating wealth in terms of seignorage through the issuance of base money. The reason is that base money is listed on the liability side and the assets received in exchange

[294] See Klein and Neumann 1990, Neumann 1992, Lange 1995 and Neumann 1996 for further analyses.

[295] Figure 7.5 depicts a stylized central bank balance sheet based on several simplifications. For instance, no gold or foreign exchange reserves are taken into account and non-monetary liabilities as well as central bank equity are neglected. Central bank balance sheets have always been surrounded by some mystique, mainly due to the accounting of the monetary base as a liability despite it de facto being no true economic liability. See Stella 1997, Hawkins 2003, Martínez-Resano 2004, Buiter 2007, 2008a, Caruana 2012, Reis 2013 as well as Miles and Schanz 2014 for analyses and discussions of central bank balance sheets. See Vergote et al. 2010, Buiter and Rahbari 2012a,b and Reis 2013 for discussions in the context of the Eurosystem.

Figure 7.5: Stylized central bank balance sheet

ASSETS	LIABILITIES
loans (L) purchased securities (A)	monetary base (M) banknotes reserves of commcercial banks

Source: author's illustration.

for base money are listed on the asset side. Therefore, the issuance of base money is neutral from an accounting perspective: as both the asset and the liability side grow simultaneously, no wealth is generated. However, while the assets are remunerated, base money is no true liability (see above). Therefore, the central bank receives interest payments on the assets without any repayment obligation for the liabilities. The asset-side approach to measure the income from money creation is developed as follows. First, the approach is presented under certainty, before uncertainty is introduced as the assets backing the monetary base are subject to default risk. It is shown that seignorage may be volatile and lower than under certainty as potential write-off losses would ceteris paribus imply a permanent deterioration in interest income.

Income from Lending under Certainty

When the central bank grants loans with a nominal value L and duration T, the relation between the present value of all income flows from the loans (V_L) and its nominal value is described by[296]

$$V_L = i_L L \left(\frac{1-(1+\beta)^{-T}}{\beta} \right) + L(1+\beta)^{-T}, \tag{7.6}$$

with i_L being the interest rate that the central bank charges on the loans.[297] With $i_L = \beta$ (i.e. the central bank charges an interest rate that is equal to the discount rate), the present value of interest payments from the loan corresponds to its nominal value, i.e. $V_L = L$. However, if the central bank charges an interest rate lower than the discount rate, i.e. $i_L < \beta$, the present value of interest payments is smaller than the nominal value, i.e. $V_L < L$. The case $V_L < L$ holds particular interest as the difference between V_L and L can be interpreted as an implicit interest subsidy that the central bank provides to its counterparties by charging an overly-low interest rate.[298]

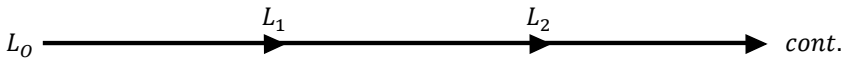
The central bank grants a chain of loans in which replacement loans are given upon the maturity of prior loans. Consider the simple chain of one-period loans (i.e. $T = 1$) as depicted in Figure 7.6.

[296] See the appendix for the derivation of Equation (7.6).

[297] For the Eurosystem, i_L is given by the interest rate applied in open market operations, i.e. the main refinancing rate (MRR), see Vergote et al. 2010. The MRR is uniform to all counterparties such that it does not reflect counterparty risk (see Section 4.2).

[298] See e.g. Klein and Neumann 1990, van Ewijk 1992 and Buiter 2007. If the central bank lends at short term and earns interest free of default risk, β can be proxied by the risk-free rate and the interest subsidy is described by $(\beta - i_L)\left[(1-(1+\beta)^{-T})/\beta\right]$. Note that this may only constitute part of the subsidy, whereas the total subsidy is measured by the difference between the interest rate that counterparties would have to pay for a comparable loan in the interbank market and the central bank interest rate. Buiter and Rahbari 2012b estimate the implicit subsidy from the Eurosystem longer-term refinancing operations as EUR 30 bn per year.

Figure 7.6: Infinite chain of central bank loans under certainty



Source: author's illustration.

Let L_0 denote the nominal value of initial loans granted at time $t = 0$ and L_j with $j = \{1, \ldots, \infty\}$ the constant nominal values of all replacement loans. The present value of payments generated by the chain of loans, i.e. V_L, is determined by using $T = 1$ and solving Equation (7.6) recursively such that[299]

$$V_L = i_L L_0 \left(\frac{1 - (1+\beta)^{-1}}{\beta} \right) \sum_{j=0}^{n} (1+\beta)^{-j} + L_j (1+\beta)^{-(j+1)}. \tag{7.7}$$

When the chain of loans is considered to be infinite, i.e. $j \to \infty$, V_L simplifies to

$$V_L = \frac{i_L}{\beta} L_0. \tag{7.8}$$

Therefore, the present value of granting loans to the private sector over an infinite horizon pays the central bank an interest rate stream in terms of a perpetuity. With $i_L = \beta$, this perpetuity is exactly equal to the nominal value of the loan.

Income from Asset Purchases under Certainty

Likewise, the central bank can create base money by purchasing both public and private securities to the amount of A_0, i.e. government bonds and private securities such as covered bank bonds or asset-backed securities. As the central bank usually acquires assets traded in the secondary market, a market value exists for the assets. This market value can be expressed in terms of the present value of income flows on the securities V_A analogous to above, i.e.

$$V_A = i_A A_0 \left(\frac{1 - (1+\beta)^{-1}}{\beta} \right) \sum_{j=0}^{n} (1+\beta)^{-j} + A_j (1+\beta)^{-(j+1)}. \tag{7.9}$$

If securities are infinitely replaced by newly purchased securities (i.e. $T \to \infty$) for the purpose of steady base money creation, the present value simplifies to

$$V_A = \frac{i_A}{\beta} A_0, \tag{7.10}$$

with i_A being the interest rate on purchased assets.

Income from Money Creation under Certainty

It was argued above that accounting principles cannot contribute to revealing the income from money creation. However, they help to explore the relation between the conventional liability-side approaches presented above and the asset-side approach. Seignorage measured by the

[299] See the appendix for the derivation of Equation (7.7).

asset-side approach (δ_{as}) comprises the sum of interest flows from both loans and purchased assets in present value terms, i.e.

$$\delta_{as} = V_L + V_A. \tag{7.11}$$

In a static calculation, seignorage corresponds to the present value of interest flows from loans granted and assets purchased to back the current monetary base, as well as all replacement loans and assets. Therefore, seignorage in a static consideration amounts to

$$\delta_{stat}^{as} = V_L + V_A = \frac{i_L}{\beta} L_0 + \frac{i_A}{\beta} A_0 = (i_L L_0 + i_A A_0) \frac{1}{\beta}. \tag{7.12}$$

In all future periods, the central bank can expand the monetary base to account for e.g. economic growth and receives additional interest-bearing assets. The present value of additional income that these assets generate is taken into account in a dynamic calculation. Under the assumption that the economy grows at the constant rate g, which is smaller than the discount rate, i.e. $\beta > g$, dynamic seignorage δ_{as}^{dyn} comprises static seignorage (i.e. seignorage accruing from today's stock of interest-bearing assets) and the present value of interest payments from loans issued and assets purchased to back future base money issuance, i.e.[300]

$$\delta_{as}^{dyn} = \delta_{as}^{stat} + \sum_{t=1}^{\infty} \frac{g\left(\frac{i_L}{\beta} L_{t-1} + \frac{i_A}{\beta} A_{t-1}\right)}{(1+\beta)^t} = (i_L L_0 + i_A A_0) \frac{1}{\beta - g}. \tag{7.13}$$

Therefore, seignorage in a dynamic calculation accounts for growth in the monetary base, which leads to additional income equal to the present value of interest on loans granted and securities bought until today and in the future. Proposition 7.1 summarizes the results for seignorage under certainty.

Proposition 7.1 (**Seignorage under certainty**). *In a certain world in which the assets backing the monetary base are not subject to default risk, static seignorage measured by the asset-side approach is given by Equation (7.12), and dynamic seignorage, i.e. allowing for future growth of the monetary base, is determined by Equation (7.13). Hence, seignorage under certainty is crucially determined by (i) the value of loans granted and securities purchased, as well as (ii) the interest rate on these loans and securities.*

Thus far, it has been assumed that the central bank acts in a certain world, i.e. loans that it grants and assets that it purchases are free of default risk. Accordingly, it was implicitly assumed that the success probability of granted loans and purchased assets was equal to unity. However, in reality, loans and assets are subject to default risk, which has to be borne by the central bank. In this case, $0 \leq p_L < 1$ and $0 \leq p_A < 1$, with p_L being the success probability of a loan and p_A the success probability of a purchased asset. If future cash flows are uncertain, literature proposes two methods to adjust the present value of interest flows received by the risk-neutral central bank (Robicheck and Myers 1966, Rubinstein 1973, Fama 1977):

i) certainty equivalent method,
ii) risk-adjusted discount rates method.

[300] See the appendix for the derivation of Equation (7.13).

While the former method replaces expected cash flows by certainty equivalent cash flows in the present value formulation, the latter calls for adjustment of the discount factor. The former method is applied in the following as it follows directly from microeconomic utility theory and matches the purpose of the analysis. Hence, the certainty equivalent CE of the cash flow in each period t CF_t is determined, i.e. the payment that makes the central bank indifferent between risk-free and risky cash flows. As the central bank is considered risk-neutral, $CE(CF_t)$ corresponds to the expected value of the cash flow, $\mathbb{E}(CF_t)$, which implies the following expression for the present value of uncertain cash flows:

$$V = \sum_{t=1}^{T} \frac{CE(CF_t)}{(1+\beta)^t} = \sum_{t=1}^{T} \frac{\mathbb{E}(CF_t)}{(1+\beta)^t}. \tag{7.14}$$

Income from Lending under Uncertainty

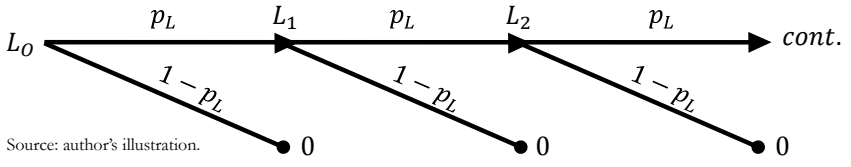
Initially, the situation is considered in which the central bank grants uncollateralized loans such that it does not receive anything in case of default. The present value of a T-period uncollateralized loan of value L is expressed in terms of its uncertain payment flows such that the analogous to Equation (7.6) under uncertainty is

$$\begin{aligned} V_L &= \sum_{t=1}^{T} \frac{\mathbb{E}(i_L L)}{(1+\beta)^t} + \frac{\mathbb{E}(L)}{(1+\beta)^T} = \sum_{t=1}^{T} \frac{p_L^t i_L L}{(1+\beta)^t} + \frac{p_L^T L}{(1+\beta)^T} \\ &= i_L L \left(\frac{p_L - (1+\beta)^{-T} p_L^{1+T}}{1+\beta-p_L} \right) + p_L^T L (1+\beta)^{-T}, \end{aligned} \tag{7.15}$$

with p_L being the constant success probability.[301]

Consider a chain of one-period loans, i.e. $T = 1$, in which the initial loan of value L_0 is repeatedly replaced. The initial loan L_0 is granted to the counterparty with the probability of success p_L. Whenever the loan does not default and is fully repaid, the central bank can inflation-neutrally grant a new loan in the same nominal value, abstracting from economic growth for the moment. However, when the loan defaults, the central bank is left with nothing and no replacement loan is granted. The chain of loans is depicted in Figure 7.7.

Figure 7.7: Infinite chain of uncollateralized central bank loans under uncertainty



Source: author's illustration.

The present value of this chain of loans V_L is determined analogously to Equation (7.7), i.e.[302]

$$V_L = i_L L_0 \left(\frac{p_L - (1+\beta)^{-1} p_L^2}{1+\beta-p_L} \right) \sum_{j=0}^{n} p_L^j (1+\beta)^{-j} + p_L^{j+1} L_j (1+\beta)^{-(j+1)}. \tag{7.16}$$

[301] The case of certainty is mimicked for $p_L = 1$, i.e. Equations (7.15) and (7.6) coincide.
[302] See the appendix for the derivation of Equation (7.16).

With an infinite chain of loans ($j \to \infty$), V_L simplifies to

$$V_L = i_L L_0 \frac{p_L}{1 + \beta - p_L}. \tag{7.17}$$

Partial derivation of V_L with respect to p_L gives

$$\frac{\partial V_L}{\partial p_L} = i_L L_0 \frac{(1+\beta)}{(1+\beta-p_L)^2} > 0, \tag{7.18}$$

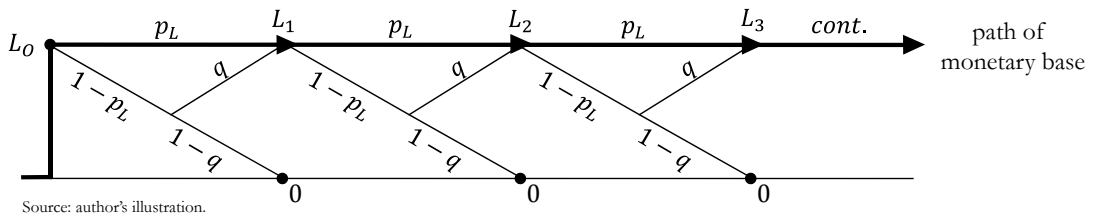
which represents the marginal effect of a variation in the success probability on the present value of the loan. The relation is strictly positive, which reveals that the present value increases in the success probability of the loan.

Thus far, uncollateralized lending has been examined, although previous analysis however showed that NCBs grant refinancing credit against collateral. In case of loan default, the central bank is left with collateral, which can be liquidated for compensation. Moreover, collateral assets are subject to default risk. Let q indicate the credit risk of collateral, i.e. q is the success probability of collateral. Let $\mathbb{E}(\Phi)$ be the expected collateral value, i.e. the value that the central bank expects to receive from liquidating the collateral. For now, this value is assumed to be L if the collateral survives but zero otherwise, i.e.

$$\Phi = \begin{cases} L & \text{with} \quad q; \\ 0 & \text{with} \quad 1-q. \end{cases} \tag{7.19}$$

The infinite chain of collateralized loans and its relation to the path of the monetary base is depicted in Figure 7.8. The path of the monetary base is fully determined by the initial loan L_0 as (if loans were the only means of base money creation) the monetary base is equal to the nominal value of the loan. Therefore, the monetary base soars with the granting of L_0 and remains constant in this static consideration, i.e. the initial loan is replaced by loans of equal volume. In the static case and irrespective of loan default, the monetary base is equal to the nominal value of the initial loan. Whether the present value of interest payments is also equal to the nominal value (and hence the monetary base) depends on loan default: if loans are repaid in every period, the present value of interest payments is equal to the monetary base. The same is true for loan default if the nominal value can be recovered from collateral liquidation. However, if both the loan and the collateral default, the central bank would lose all current and future interest payments.

Figure 7.8: Infinite static chain of collateralized central bank loans under uncertainty



Source: author's illustration.

The present value of interest payments on the initial loan is equal to

$$V_L = p_L \left(\frac{i_L L_0}{1+\beta} \right) + (1-p_L) q \left(\frac{i_L L_0}{1+\beta} \right). \tag{7.20}$$

It has been assumed thus far that if collateral survived, the expected liquidation value would be exactly equal to the interest payment. However, in reality, the liquidation value may fall short of the nominal value of the loan, e.g. by the fraction $1-\kappa$. Therefore, the liquidation value of collateral changes to

$$\Phi = \begin{cases} \kappa L & \text{with} \quad q; \\ 0 & \text{with} \quad 1-q, \end{cases} \tag{7.21}$$

with $0 \leq \kappa \leq 1$ reflecting liquidity of collateral (see above) or the recovery rate, respectively. Hence, the present value of interest payments on the initial one-period loan L_0 becomes

$$V_L = p_L \left(\frac{i_L L_0}{1+\beta} \right) + (1-p_L) q \left(\frac{\kappa i_L L_0}{1+\beta} \right). \tag{7.22}$$

Figure 7.9 illustrates the infinite chain of collateral central bank loans, the present value of interest payments from it and the path of the monetary base. Without default, the present value of interest flows coincides with the path of the monetary base. The dashed curve represents all potential liquidation values κL_1 in case of loan default. A situation with $\kappa L_1 < L_1$ is depicted in dark blue, confirming that a one-time write-off to the amount of $(1-\kappa)L_0$ on the loan leads to a permanent loss in interest income. While the path of the monetary base is unaffected (being equal to the present value of interest income that the central bank would have received in the absence of default), the present value of interest income is permanently reduced since replacement loans to the amount of $\kappa L_1 < L_0$ can be granted after default without causing inflation risk. In case of default in future periods, the loss in seignorage would be aggravated.

The present value of interest payments of the n-period chain of one-period collateralized loans under uncertainty reads as

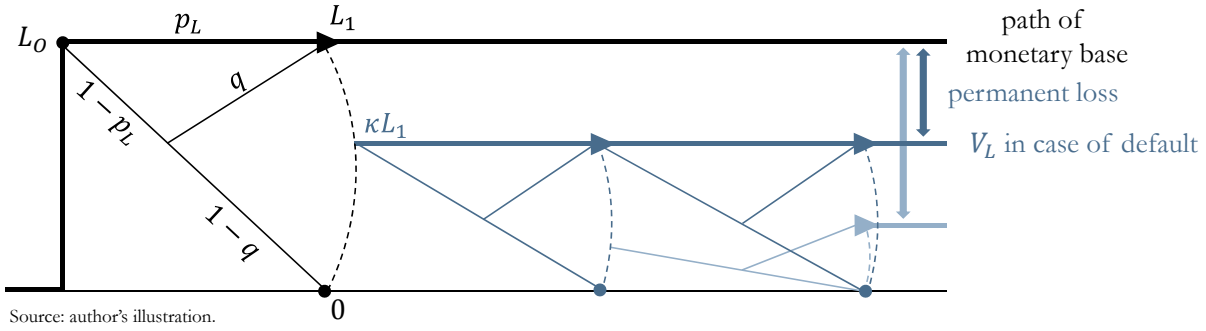
$$\begin{aligned} V_L &= \underbrace{i_L L_0 \frac{p_L + (1-p_L)q\kappa}{(1+\beta)}}_{\text{initial loan}} \\ &\quad + \underbrace{i_L L_0 \frac{p_L^2 + p(1-p_L)q\kappa + p_L(1-p_L)q\kappa + (1-p_L)^2 q^2 \kappa^2}{(1+\beta)^2}}_{\text{first replacement loan}} + \ldots \\ &= i_L L_0 \sum_{j=1}^{n} \frac{(p_L + (1-p_L)q\kappa)^j}{(1+\beta)^j}. \end{aligned} \tag{7.23}$$

The consideration of an infinite chain of refinancing loans (i.e. $j \to \infty$) simplifies V_L to[303]

$$V_L = i_L L_0 \frac{p_L + (1-p_L)q\kappa}{1+\beta-p_L-(1-p_L)q\kappa}. \tag{7.24}$$

[303] Plugging in $p_L = 1$ replicates the case of certainty, i.e. Equation (7.8).

Figure 7.9: Infinite static chain of collat. central bank loans under uncertainty; $\kappa \in [0, 1]$



Source: author's illustration.

Income from Asset Purchases under Uncertainty

The central bank can also buy public and private assets in the market to create base money. Equation (7.10) describes the present value of purchased securities, respectively, under uncertainty as a perpetuity of interest payments, i.e.

$$V_A = i_A A_0 \frac{p_A}{1+\beta-p_A}, \tag{7.25}$$

with p_A being the success probability of a purchased security. A comparison of Equations (7.25) and (7.17) indicates that the present value of purchased assets is equivalent in its structure to that of an uncollateralized loan.

Income from Money Creation under Uncertainty

Seignorage under uncertainty is determined analogously to the case under certainty described above. Static seignorage from granting collateralized loans and purchasing public and private securities that are subject to default risk reads as

$$\delta_{as}^{stat} = V_L + V_A = i_L L_0 \frac{p_L + (1-p_L)q\kappa}{1+\beta-p_L-(1-p_L)q\kappa} + i_A A_0 \frac{p_A}{1+\beta-p_A}. \tag{7.26}$$

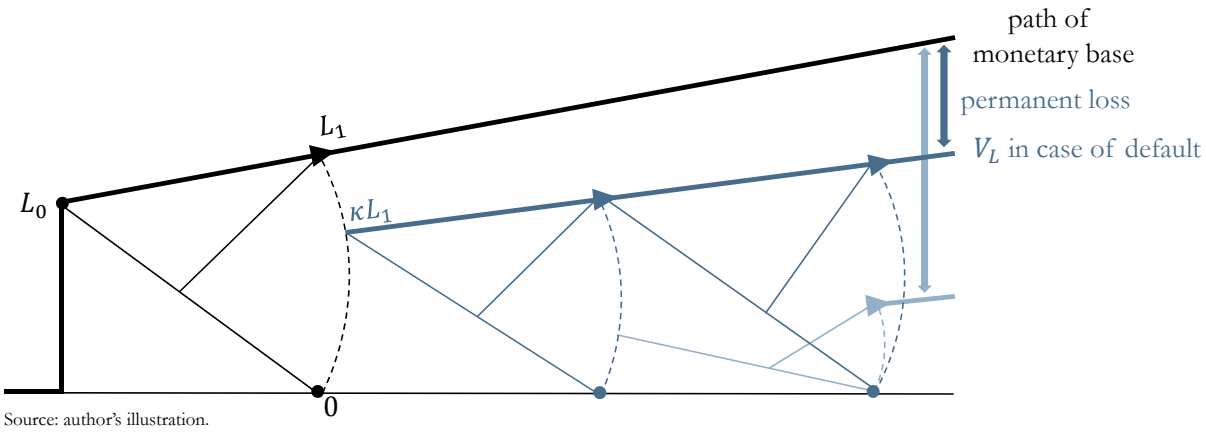
In a dynamic consideration, the central bank realizes interest income to the amount of

$$\begin{aligned} \delta_{as}^{dyn} &= \delta_{as}^{stat} + \sum_{t=1}^{\infty} \frac{g\left(i_L L_{t-1} \frac{p_L+(1-p_L)q\kappa}{1+\beta-p_L-(1-p_L)q\kappa} + i_A A_{t-1} \frac{p_A}{1+\beta-p_A}\right)}{(1+\beta)^t} \\ &= \left(i_L L_0 \frac{p_L+(1-p_L)q\kappa}{1+\beta-p_L-(1-p_L)q\kappa} + i_A A_0 \frac{p_A}{1+\beta-p_A}\right) \frac{\beta}{\beta-g}. \end{aligned} \tag{7.27}$$

The amplified importance of counterparty and collateral quality for a growing economy is revealed by Figure 7.10, which is the counterpart to Figure 7.9 for the dynamic case in which the monetary base (which is assumed to be generated by collateralized lending only, for clarity) steadily grows in lockstep with the economy. While write-off to the initial or any replacement loan implied a permanent yet constant loss in interest income in the static case, the loss is no longer constant in the dynamic case. As the present value of interest income without de-

fault would grow in line with the path of the monetary base, any write-off implies a loss that aggravates in every period.

Figure 7.10: Infinite dynamic chain of collat. central bank loans under uncertainty; $\kappa \in [0,1]$



Source: author's illustration.

Proposition 7.2 outlines the results of the analysis of the income from money creation that can be claimed by the central bank under uncertainty.

Proposition 7.2 (**Seignorage under uncertainty**). *In an uncertain world in which the assets backing the monetary base are subject to default risk, static seignorage measured by the asset-side approach is given by Equation (7.26) and dynamic seignorage by Equation (7.27). Under uncertainty, seignorage is additionally determined by (i) counterparty default risk, (ii) collateral default risk and (iii) collateral liquidity risk.*

7.3.1.3 Evaluation of Income from Money Creation for the Eurosystem

The previous section identified five determinants of interest income from money creation, i.e. *(i)* the volume of collateralized loans and securities granted/purchased by the central bank; *(ii)* the interest rate on these loans and securities; *(iii)* the default risk of loans and purchased securities; *(iv)* the default risk of collateral; and *(v)* the liquidity risk of collateral. This section further elaborates on the determinants in two ways: first, general effects of variations in the determinants on the present value of interest income are derived; and second, the development of the determinants is evaluated for the Eurosystem.[304,305]

Volume and Interest Rate of Collateralized Loans and Purchased Securities

Comparative statistics with respect to variations in volume and interest rate give

$$\frac{\partial \delta_{as}^{stat}}{\partial L_0} = i_L \frac{p_L + (1-p_L)q\kappa}{1+\beta-p_L-(1-p_L)q\kappa} > 0; \quad \frac{\partial \delta_{as}^{stat}}{\partial i_L} = L_0 \frac{p_L + (1-p_L)q\kappa}{1+\beta-p_L-(1-p_L)q\kappa} > 0;$$

[304] General effects are derived for static seignorage under uncertainty, as given by Equation (7.26). Qualitative results hold analogously for dynamic seignorage. The growth rate of the economy is another determinant of seignorage in a dynamic consideration, although this is not at discretion of the central bank.

[305] The evaluation of determinants is largely restricted to collateralized loans as necessary information on purchased securities is not available.

$$\frac{\partial \delta_{as}^{stat}}{\partial A_0} = i_A \frac{p_A}{1+\beta-p_A} > 0; \qquad \frac{\partial \delta_{as}^{stat}}{\partial i_A} = A_0 \frac{p_A}{1+\beta-p_A} > 0.$$

Changes in both the volume and the interest rate positively affect seignorage.[306] Moreover, changes in volume or interest rate have ceteris paribus larger marginal effects on seignorage for collateralized loans than for purchased securities.[307] This is particularly important as the central bank has discretion to determine the interest rate in collateralized loans. Vergote et al. 2010 emphasize that the volume of loans and the interest rate have been crucial for the development of central bank income in the Eurosystem in recent years. Figure 2.2 revealed that the Eurosystem considerably increased liquidity provision in terms of collateralized loans and security purchases, which should have boosted income. However, extended liquidity provision by collateralized lending was accompanied by a historically low interest rate (cf. Figure 2.6).

Counterparty Risk

Variation in counterparty risk involved in loans and purchased securities bears the following marginal effects on seignorage:

$$\frac{\partial \delta_{as}^{stat}}{\partial p_L} = i_L L_0 \frac{(1+\beta)(1-q\kappa)}{(1+\beta-p_L-(1-p_L)q\kappa)^2} > 0; \tag{7.28}$$

$$\frac{\partial \delta_{as}^{stat}}{\partial p_A} = i_A A_0 \frac{(1+\beta)}{(1+\beta-p_A)^2} > 0. \tag{7.29}$$

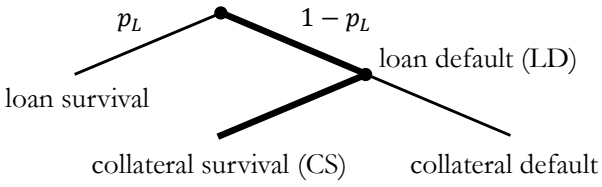
Equations (7.28) and (7.29) reflect the importance of the risk-hedging effect of collateral. The acquisition of securities de facto inherits the same risk implications as *uncollateralized* loans. The central bank only has to write off *collateralized* loans in case of double default, i.e. the default of both counterparty and collateral, although it already has to write off purchased securities in case of (single) counterparty default.

This general assertion is only valid for the implicit assumption that the success probabilities of the loan and collateral are independent. However, in reality, the success probabilities may be correlated owing to links between the counterparty and the collateral issuer ("wrong-way risk", see Section 4.2). Figure 7.11 shows the course of action in case of a collateralized loan (see also above). The loan is repaid with probability p_L and collateral is irrelevant in such a case. With loan default ("LD"), the central bank has to liquidate collateral in case of collateral survival ("CS") and it has to fully write off the loan otherwise. Figure 7.11 highlights the vital course of events for the conditionality of success probabilities. Three different cases that differ in the extent of wrong-way risk are considered in the following, the first of which recapitulates independence, the second "close links" and the third "own-use".

[306] While the numerator is strictly positive, the condition for a positive denominator in case of collateralized loans is $1+\beta > p_L+(1-p_L)q\kappa$, which holds for all $p_L, q, \kappa \in [0,1]$ and $\beta > 0$. The equivalent condition for purchased securities is $1+\beta > p_A$, which holds for $p_A \in [0,1]$ and $\beta > 0$.

[307] This holds given equal counterparty risk as the numerator is larger and the denominator smaller for collateralized loans than for purchased securities with $q, \kappa \in [0,1]$ and $\beta > 0$.

Figure 7.11: Course of events for collateralized loan under uncertainty



Source: author's illustration.

Case 1 ("independence"): In this case, success probabilities are independent such that the probability of both events LD and CS taking place is given by

$$Prob(CS \cap LD) = Prob(LD) \cdot Prob(CS) = (1 - p_L) \cdot q, \tag{7.30}$$

where q is again the success probability of collateral such that the present value is equal to that derived in Equation (7.24), i.e.

$$V_{1,L} = i_L L_0 \frac{p_L + (1 - p_L)q\kappa}{1 + \beta - p_L - (1 - p_L)q\kappa}. \tag{7.31}$$

Case 2 ("close links"): This case assumes close links between the counterparty and the collateral issuer. Close links would make collateral default more likely if the counterparty defaulted such that the success probability of collateral is conditional on the counterparty success probability. The conditional probability that collateral survives after loan default is

$$Prob(CS|LD) = \frac{Prob(CS \cap LD)}{Prob(LD)} = \frac{Prob(CS \cap LD)}{1 - p_L} \equiv \chi \tag{7.32}$$

such that the probability of CS taking place after LD is

$$Prob(CS \cap LD) = (1 - p_L)\chi, \tag{7.33}$$

where χ is the probability of collateral survival after loan default with close links between the counterparty and the collateral issuer. In this case, the present value reads as

$$V_{2,L} = i_L L_0 \frac{p_L + (1 - p_L)\chi\kappa}{1 + \beta - p_L - (1 - p_L)\chi\kappa}, \tag{7.34}$$

which is smaller than the present value in case of independence, i.e. $V_{2,L} < V_{1,L}$, for $\chi < q$. This holds as the success probability of collateral after counterparty default is lower for close links than in case of independence.

Case 3 ("own-use"): Own-use of collateral describes the situation in which the counterparty pledges own-use uncovered bank bonds as collateral. Therefore, collateral defaults accordingly in case of counterparty default. The probability that collateral survives after counterparty default is zero in case of own-use, which corresponds to

$$\chi = 0. \tag{7.35}$$

The present value is subsequently given by

$$V_{3,L} = i_L L_0 \frac{p_L}{1 + \beta - p_L}, \tag{7.36}$$

which resembles the present value of an uncollateralized loan, cf. Equation (7.17). This reveals that the risk profile of loans collateralized by own-use uncovered bank bonds is similar to that of uncollateralized loans and asset purchases, respectively, as the role of collateral as risk hedge de facto vanishes.[308] Despite collateralization, the central bank already has to write off these loans in case of single default. This indicates how the Eurosystem gradually approved larger exposure to counterparty risk. The analysis shows that counterparty risk is the smallest for collateralized loans in which counterparty and collateral issuer are independent, although it surges and approaches counterparty risk in asset purchases for loans collateralized by own-use uncovered bank bonds. The Eurosystem carried out this course as it increased counterparty risk exposure in two steps: first, it relaxed collateral criteria down to the eligibility of own-use uncovered bank bonds; and second, it initiated asset purchases. The duration of liquidity provision usually distinguishes counterparty risk exposure in collateralized loans from that in asset purchases as collateralized loans are usually short-term while the residual maturity of purchased assets is medium or long-term. However, Chapter 2 revealed that the Eurosystem increased the duration of collateralized loans from initially up to three months to three years and counterparties appreciated this possibility of long-term funding (Figure 2.5). Since this extension, the duration of collateralized loans is only slightly below the average residual maturity of e.g. government bonds purchased under the SMP (Table 2.4). Therefore, the Eurosystem gradually increased its counterparty risk exposure by watering down the risk hedge in collateralized lending and extending the duration of collateralized loans close to that of purchased assets.

The notion that counterparty risk is relevant to the Eurosystem was revealed in the fall of 2008 when five counterparties defaulted on their loans to the total value of EUR 10.3 bn.[309] Complementing this anecdotal evidence, Figure 7.12 provides an indication concerning the development of counterparty risk from 2008 to 2014 based on the EU banks credit default swap (CDS) index (5Y).[310] Despite being a measure for the entire EU banking sector, the index serves as an appropriate proxy to counterparty risk as the Eurosystem gives loans to a very broad range of counterparties.[311] The figure reveals that counterparty risk has been volatile over recent years, increasing during the fall of 2008 and throughout the sovereign debt crisis.

[308] See also Cour-Thimann and Winkler 2013, Claeys et al. 2014 as well as ECB 2015c on comparisons of the (risk) implications of collateralized loans and asset purchases. The financial risk of central bank asset purchases is unraveled in Stone et al. 2011.

[309] See ECB 2009, "Eurosystem Monetary Policy Operations in 2008," *Press Release*, 5 March 2009, Sibert 2009 as well as Belke and Polleit 2010. According to the ECB, loans under default were mainly collateralized by highly complex ABSs of limited liquidity. The Deutsche Bundesbank was the largest creditor with a total value of EUR 8.5 bn. Liquidation of collateral took more than four years and brought EUR 7.4 bn, leaving the Deutsche Bundesbank as a creditor in the Lehman Brothers bankruptcy proceedings with a residual claim of EUR 1.9 bn (including interest), see Deutsche Bundesbank, "Conclusion of Resolution of Lehman Collateral," *Press Release*, 20 February 2013, as well as Bindseil and Jablecki 2013. See also Deutsche Bundesbank, "Bundesbank hat letzte Zahlung aus dem deutschen Lehman-Insolvenzverfahren erhalten," *Press Release*, 10 February 2015.

[310] The index refers to counterparty risk as it measures the premium that EU banks had to pay to obtain a CDS as protection against default: accordingly, the higher the index, the larger the market anticipation of default.

[311] By the end of 2014, the ECB listed 8,296 monetary financial institutions in the EU, 5,555 of which were deemed eligible counterparties (ECB 2011d). See also Section 2.3.

Figure 7.12: Default risk of Eurosystem counterparties

The figure depicts the development of the EU banks CDS index (5Y) from 2008 to 2014. The index provides an indication concerning the development of counterparty risk to the Eurosystem, suggesting that it increased over time and peaked throughout the financial crisis and the sovereign debt crisis.

Source: author's illustration; Thomson Reuters Datastream.

Collateral Quality

Counterparty default would only pose a risk to interest income from lending if collateral quality was insufficient. When collateral defaults or is illiquid, the central bank cannot recover its financial position in case of counterparty default, i.e. the position that it would have had if the loan had been repaid. Instead, the central bank has to write off (at least a fraction) of the loan. Hence, collateral quality that manifests in default risk and liquidity risk of collateral is basal. The following analysis considers collateral default risk in terms of the (unconditional) success probability q and collateral liquidity risk in terms of liquidity κ.

Collateral Default Risk The marginal effect of a change in default risk on seignorage is characterized by

$$\frac{\partial \delta_{as}^{stat}}{\partial q} = i_L L_0 \frac{(1+\beta)(1-p_L)\kappa}{(1+\beta-p_L-(1-p_L)q\kappa)^2} > 0. \tag{7.37}$$

Hence, a rise in default risk (i.e. a decrease in q) implies lower seignorage.[312] The development of default risk in the Eurosystem was already extensively addressed in Sections 3.3.4 (eligible marketable assets), 5.1 (pledged collateral) and 5.4 (pledged collateral revisited). It was revealed that the default risk of eligible marketable assets increased as of October 2008 when the minimum credit rating threshold was relaxed and that the probability of default of eligible marketable and pledged collateral has substantially increased since then (Figure 5.22). Moreover, it was

[312] In case of close links, q has to be replaced by χ in Equation (7.37). As $\chi < q$ (see above), the marginal effect is still positive but larger with close links than with independence.

estimated that the credit quality of pledged collateral overproportionally deteriorated owing to the adverse selection of collateral and the increased pledge of non-marketable assets.

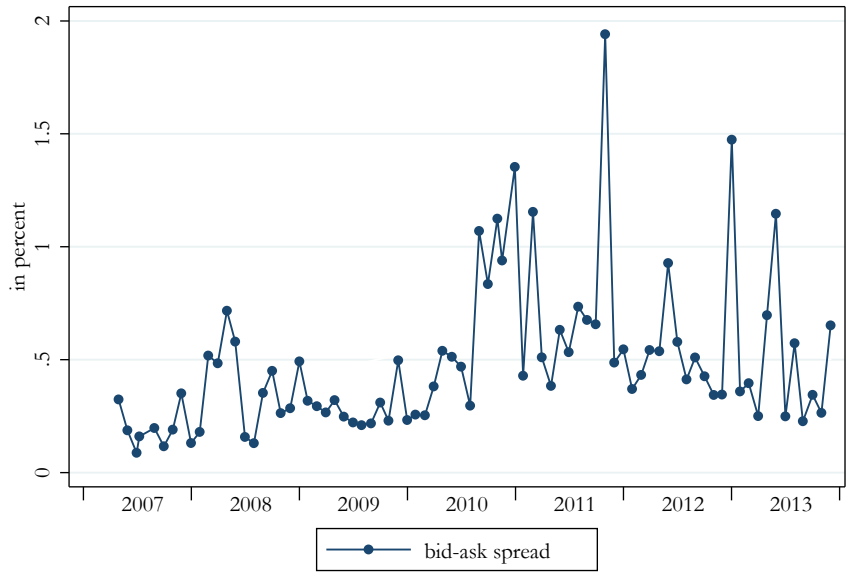
Collateral Liquidity Risk The adverse selection of collateral is also relevant for changes in collateral liquidity risk, the marginal effect of which is determined by

$$\frac{\partial \delta^{as}_{stat}}{\partial \kappa} = i_L L_0 \frac{(1+\beta)(1-p_L)q}{(1+\beta-p_L-(1-p_L)q\kappa)^2} > 0. \tag{7.38}$$

Analogous to default risk, the marginal effect is positive such that a boost of liquidity risk (i.e. a decrease in κ) implies a decrease in seignorage. The development of liquidity risk of eligible marketable assets is illustrated in Figure 7.13. The figure depicts the evolution of the median bid-ask spread of eligible marketable assets from May 2007 to December 2013 as a measure of (il)liquidity.[313] The bid-ask spread measures the difference of the ask price over the bid price relative to the ask price in percent. The larger the bid-ask spread, the less liquid the asset. The figure suggests that the liquidity of eligible marketable assets was very volatile with collateral being particularly illiquid throughout 2010 and 2013, as well as at the end of 2011. Hence, liquidity only slightly deteriorated after the outbreak of the financial crisis but considerably throughout the sovereign debt crisis, which can be attributed to the large fraction of government bonds in the eligible collateral pool. Hence, the development resembles that for collateral default risk.

Figure 7.13: Liquidity risk of eligible marketable assets

The figure depicts the development of the median bid-ask spread of eligible marketable assets from 2007 to 2013 as a measure of (il)liquidity. It indicates that the liquidity of eligible marketable assets was very volatile, with eligible assets being particularly illiquid throughout 2010 and 2013 as well as at the end of 2011.



Source: author's calculation; Bloomberg.

[313] On the bid-ask spread as the standard measure of (il)liquidity, see e.g. Edwards et al. 2007 and Goldstein et al. 2007. The author collected bid prices and ask prices from Bloomberg for eligible marketable assets, where available.

This section has revealed that uncertainty adversely affects seignorage and hence central bank finances. Default on refinancing loans and purchased assets imply a permanent deterioration of central bank income. Evaluating the determinants of seignorage for the Eurosystem indicates that it was at risk owing to a combination of *(i)* a low interest rate, *(ii)* increased counterparty risk and *(iii)* deteriorating collateral quality in terms of higher default and liquidity risk. While write-off losses have been limited to date, the deterioration of collateral quality (inter alia owing to adverse selection of collateral) is particularly alarming. While potential write-off losses owing to low-quality collateral would be relatively small in a low interest rate environment, they would not be restricted to the short term but would rather induce a permanent decrease in seignorage. This puts at risk interest income from money creation as a major source of central bank income.

7.3.2 Collateral Criteria and Emergency Liquidity Assistance

This section argues that Emergency Liquidity Assistance (ELA) provided in the Eurozone is closely linked to the Eurosystem collateral framework and intensifies risk to central bank income. ELA is the facility through which NCBs can fund local counterparties that have lost market access and are unable to participate in standard refinancing operations under specific conditions and against collateral.[314] It is grounded in Article 14.4 of the Statue of the ESCB and the ECB. The article decrees that ELA is "performed on the responsibility and liability of NCBs" (ECB 2012e, p. 237) as it is not considered part of the single monetary policy of the Eurosystem. Therefore, potential losses from ELA are de jure not shared among NCBs (like for ordinary refinancing operations) but fully borne by the NCB that provides it. Moreover, the article determines that the ECB Governing Council can veto the provision of ELA by a majority of two-thirds. Further specifications for ELA procedures were published by the ECB in October 2013, although they aimed at ensuring adequate information flow within the Eurosystem, i.e. from NCBs to the ECB, rather than improving public disclosure of ELA (ECB 2013b).

ELA is presumably provided against different conditions than conventional refinancing loans as the responsible NCB has discretion over the maturity, interest rate, collateral criteria and the haircut (albeit which the ECB can veto). While the interest rate is supposed to be higher than in conventional refinancing operations as a penalty mark-up is charged,[315] collateral criteria are supposed to be laxer; otherwise, ELA would be unnecessary if the counterparty possessed sufficient collateral complying with the uniform collateral criteria under the full allotment of refinancing credit. This makes the collateral framework and ELA inherently linked. On the one hand, the collateral framework steers collateral availability, whereby low collateral availability owing to a strict framework makes it more likely that counterparties strive for ELA. On the other hand, the responsible NCB has discretion to determine collateral criteria for ELA such that a relaxed uniform collateral framework would imply even lower collateral criteria for ELA.

[314] See Buiter et al. 2011, Lattuga and Valli 2012, Sinn 2012, 2014b, ECB 2013b, Illing and König 2014 and Whelan 2014b for further information and analyses of ELA. See Fuest and Sinn 2015 for a discussion of the risk implications.

[315] This mark-up (difference between the ELA interest rate and the MRR) is shared among NCBs, see ECB 2011a and Sinn 2014b.

The NCBs of Belgium, Germany, Greece, Ireland and Cyprus have most likely granted ELA in recent years. Accordingly, they have supported local banks that lacked collateral complying with the Eurosystem collateral framework despite its extensive relaxation.[316] With NCBs of Greece, Ireland and Cyprus, these were NCBs of crisis-stricken countries for which the previous analysis suggested temporary collateral scarcity (see Chapter 1). Tracking the development of the ELA volume is difficult as its quantity is not specifically disclosed, whereby only a proxy is available from monthly financial statements of NCBs.[317] The approximated development is illustrated in Figure 7.14. January 2008 is used as the reference month to capture the effects of the crises. The Deutsche Bundesbank and the Banque Nationale de Belgique provided ELA in specific situations for limited periods: the Deutsche Bundesbank provided EUR 35 bn to the Hypo Real Estate and the Banque Nationale de Belgique to Fortis to the peak amount of EUR 51.3 bn. ELA given by the Bank of Greece surged to a level slightly above EUR 50 bn during the second half of 2011 and jumped to EUR 109.4 bn in February 2012 when the Eurosystem temporarily revoked the suspension of the minimum credit rating for collateral linked to the Greek government (Section 3.2.2). ELA in Greece developed in a volatile manner thereafter but remained on a high level throughout 2012 and declined until the end of 2014. The Central Bank of Ireland provided ELA almost exclusively to the Irish bad bank, i.e. the National Asset Management Agency (NAMA), such that it was given earlier and on a smaller scale (peak amount of EUR 70.3 bn in February 2012). Finally, the Central Bank of Cyprus provided ELA as of April 2012 culminating to EUR 11.4 bn in March 2013. After the Eurosystem waived the minimum credit rating requirement for Cypriot government-linked collateral in May 2013, provision of ELA steadily contracted in Cyprus.

ELA bears risk to central bank finances as it is granted to financially-stricken banks against collateral of quality lower than stipulated by the Eurosystem collateral framework. Therefore, collateral risk (and likewise counterparty risk) is deemed to be higher for ELA than in standard refinancing operations. The tolerance of higher collateral risk is justified by the de jure provision that NCBs grant ELA on their own responsibility, i.e. they have to bear potential losses. This has two implications: on the one hand, it poses substantial risk to the financial strength of the respective NCB, which makes recapitalization more likely; and on the other hand, it constitutes a de jure provision that may not be sustainable in reality. The liability of NCBs is de facto limited to their capital in addition to their entitlement to the present value of interest income of the Eurosystem (neglecting potential minimum reserves, see Sinn 2014b). Accordingly, write-off losses on ELA in terms of permanent foregone interest income (see above) would be shared among NCBs if they exceeded the liability amount of the NCB that has granted ELA.

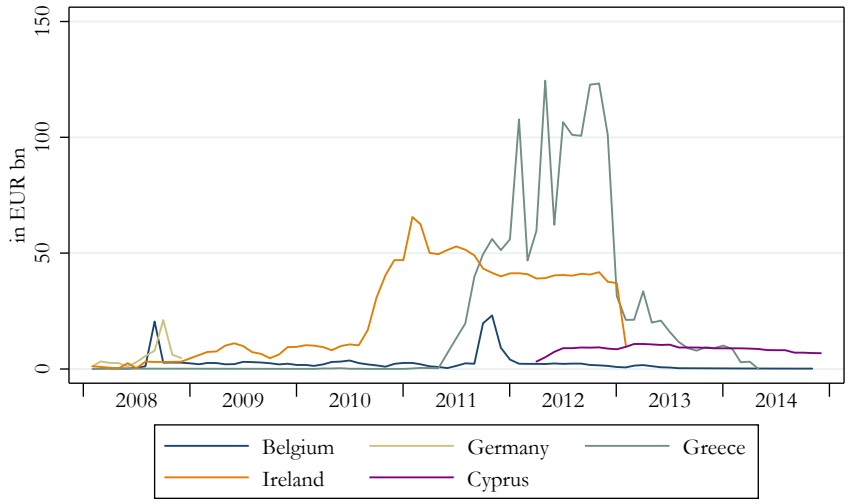
Hence, ELA potentially affects not only the financial strength of the NCB that provided it and de jure bears all losses from the provision, but also the other NCBs owing to the de facto limited liability of the responsible NCB. The general reasoning of the previous section that income from money creation is put at risk by relaxations of collateral criteria is fostered for ELA. As ELA

[316] Data for the entire Eurosystem suggests that the ECB tolerated ELA to the peak total amount of EUR 250.6 bn (June 2012). At the end of 2014, ELA amounted to 58.7 bn.

[317] ELA was accounted as the balance sheet item "other claims on Euro Area credit institutions denominated in euro" after April 2012 when accounting standards were harmonized. Prior to this harmonization, ELA was classified as "other claims on Euro Area credit institutions denominated in euro" and "other assets."

Figure 7.14: Approximated provision of Emergency Liquidity Assistance by NCBs

The figure approximates the development of ELA provided by NCBs from 2008 to 2014. January 2008 is the reference month to reflect the effects of the crises on the provision of ELA. The figure shows that the Deutsche Bundesbank and the Banque Nationale de Belgique provided ELA for limited periods, while in particular the Bank of Greece and the Central Bank of Ireland gave ELA over longer periods and on a larger scale.



Reference month: January 2008.
Belgium, Germany, Cyprus: 'Other Claims on Euro Area Credit Institutions Denominated in Euro'.
Ireland: 'Other Claims on Euro Area Credit Institutions Denominated in Euro' + 'Other Assets'.
Greece: 'Other Claims on Euro Area Credit Institutions Denominated in Euro' + 'Sundry'.
Source: author's compilation; National Central Banks.

is provided against collateral of even lower quality, any relaxation of uniform collateral criteria implicitly lowers the collateral criteria imposed in ELA and fosters risk to the interest income from money creation.[318]

7.3.3 Collateral Criteria and Intra-Eurosystem Claims/Liabilities

Intra-Eurosystem balances are a further issue for which collateral criteria are key and which imply risk to central bank finances in the Eurosystem.[319] Claims and liabilities of NCBs towards the ECB were relatively balanced prior to the financial crisis but subsequently turned into huge intra-Eurosystem imbalances. The imbalances mainly stem from Target claims and liabilities that measure the relocation of refinancing credit across Eurozone countries, reflected in the balance sheets of NCBs.[320] The relaxation of collateral criteria was key to the accumulation of Target balances, enabling NCBs to liberally and fully allot refinancing loans to liquidity-seeking

[318] However, relaxations of uniform collateral criteria similarly reduce the likelihood that ELA has to be provided. Relaxations sustain de jure risk-sharing from ordinary refinancing operations rather than transforming it into de facto risk-sharing under ELA (owing to limited liability of NCBs).

[319] Intra-Eurosystem balances are closely related to the previous issue of ELA as the provision of the latter gives rise to the accumulation of the latter, see Fuest and Sinn 2015.

[320] Target is the acronym for Trans-European Automated Real-Time Gross Settlement Express Transfer System (Target), i.e. the internal payment settlement system of the Eurosystem. Its growing importance during the crisis was unveiled by Sinn and Wollmershäuser 2012 and is comprehensively discussed in Sinn 2012, 2014b. Target balances are not addressed to the extent warranted here as focus on interest here is placed upon the fiscal implications of intra-Eurosystem balances, of which Target balances are one component. Therefore, important issues like causes of Target imbalances and their interpretation are neglected. For further discussions, see Schlesinger 2012, Neumann 2012, Bernholz 2012, Bindseil et al. 2012, Bindseil and König 2012, Bindseil and Winkler 2013, Pisani-Ferry 2013, Auer 2014, Potrafke and Reischmann 2014 as well as Whelan 2014a. A comprehensive survey of the literature is provided in Sinn 2012, 2014b and Cour-Thimann 2013.

banks. Hence, the presence of Target balances is closely related to the exceptional measures taken by the Eurosystem, i.e. the full allotment of very long-term refinancing credit at a fixed rate against low-quality collateral (see e.g. Sinn 2012, 2014b, Sinn and Wollmershäuser 2012, Neumann 2012 and Cour-Thimann 2013).

However, Target balances are just one component of intra-Eurosystem balances recorded in the balance sheet of NCBs. Intra-Eurosystem balances comprise several claims/liabilities, most importantly net claims/liabilities related to the allocation of euro banknotes within the Eurosystem besides net claims/liabilities arising from Target accounts.[321]

Intra-Eurosystem claims and liabilities resulting from underproportional or overproportional banknote issuance are similar to Target claims and liabilities in many ways, despite not being included in official national balance-of-payments statistics (Whittaker 2011, Sinn 2012, 2014b, Sinn and Wollmershäuser 2012). The over-/underproportional issuance of banknotes measures the relation between banknotes entered into circulation by an NCB and the amount of banknotes that the NCB is conceded to issue according to its share in ECB capital. In case of overproportional issuance, an outflow of physical cash to other countries is alleged, which is comparable to the outflow of book money measured by a Target claim. Hence, the overproportional issuance of banknotes incurs an intra-Eurosystem liability while an underproportional issuance of banknotes incurs an intra-Eurosystem claim.

Figure 7.15 illustrates the development of intra-Eurosystem claims and liabilities for selected countries. Positive values indicate a claim while negative values correspond to a liability. Prior to the financial crisis, Target balances were close to zero such that intra-Eurosystem balances developed stably on a small scale. The German liability originated from overproportional banknote issuance and the French claim from underproportional one.[322] Since the outset of the financial crisis, the development of intra-Eurosystem claims and liabilities has become more disperse, with Germany turning its liability into a huge claim. While liabilities were concentrated to Greece and Ireland until mid-2011, Spain and Italy converted their initial claim into a liability, which steadily grew until mid-2012. Subsequently, intra-Eurosystem claims and liabilities contracted again, although the figure reveals enormous imbalances that still prevailed at the end of 2014.

The imbalances are noteworthy as they involve liabilities of NCBs against the ECB, which are subject to potential write off. The ECB may have to write off its claim against an NCB if the latter cannot settle its liability, e.g. because the country is insolvent. This is independent from whether the insolvent country would remain in or exit the Eurozone as intra-Eurosystem claims and liabilities remain in place (Sinn 2015b).[323] However, government default would adversely

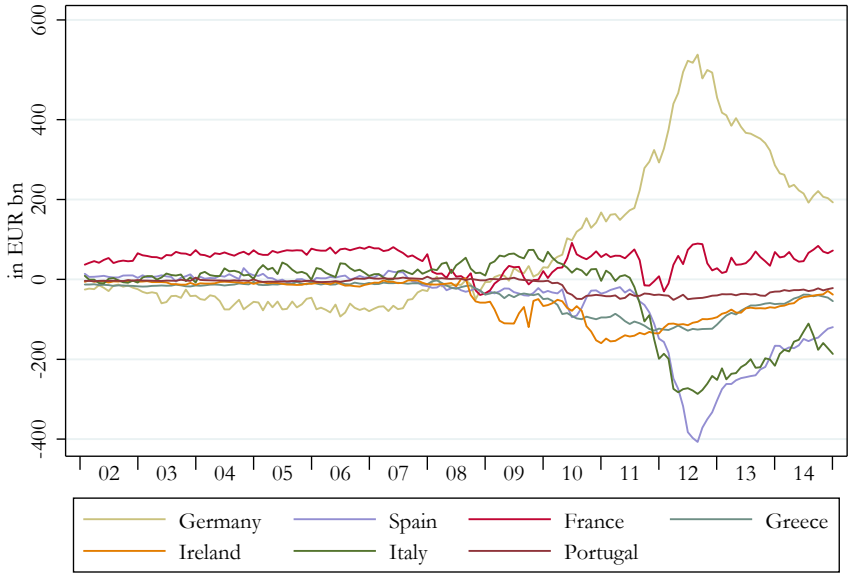
[321] Other claims are participating interest in the ECB, claims equivalent to the transfer of foreign reserves to the ECB and other net claims with the Eurosystem. Other liabilities are liabilities related to promissory notes backing the issuance of ECB debt certificates as well as other net liabilities within the Eurosystem (ECB 2012c).

[322] According to Sinn and Feist 1997 as well as Sinn 2014b, Germany's overproportional banknote issuance resulted from the enormous stock of deutschmark banknotes that circulated outside of Germany prior to the introduction of the euro. Seignorage wealth from this stock was shared in the Eurosystem and counted as a liability of the Deutsche Bundesbank. Therefore, overproportional banknote issuance developed apace with economic growth. According to Cour-Thimann 2013, Germany has overproportional issuance because extra Eurozone demand for banknotes is often addressed to German banks, as well as because German tourists withdraw cash at home and spend it abroad.

[323] Nevertheless, potential losses to NCBs may differ in both cases, see Sinn 2015b.

Figure 7.15: Intra-Eurosystem claims and liabilities

The figure details the development of intra-Eurosystem balances for selected countries from 2002 to 2014. Positive values indicate a claim while negative values correspond to a liability. Target balances were close to zero prior to the financial crisis such that intra-Eurosystem balances developed stably on a small scale. Huge liabilities were accumulated thereafter by crisis-stricken countries.



Source: author's illustration; National Central Banks; Ifo Institute.

affect NCB finances as government bonds, which are largely pledged as collateral (see Figure 5.2), would lose in value. This would increase the likelihood that the borrowing NCB fails to meet its intra-Eurosystem liability such that the ECB would have to write off the liability.[324] As NCBs would have to share the ECB loss, NCB default on its intra-Eurosystem liability would adversely affect the other NCBs in terms of an adverse shock to their balance sheet.

Consider the stylized case of two countries: the NCB of country 1 has an intra-Eurosystem claim, while the NCB of country 2 bears a corresponding intra-Eurosystem liability.[325] The stylized balance sheet of country 1's NCB is depicted in the left panel of Figure 7.16, while the right panel details the stylized balance sheet of country 2's NCB.[326] If the NCB could not redeem its liability towards the ECB, the NCB of country 1 would participate in this loss and it would have to write off a fraction of its claim, corresponding to the gray area. This write-off loss would wipe out capital of country 1's NCB and it would be left with liabilities exceeding assets, i.e. negative capital.

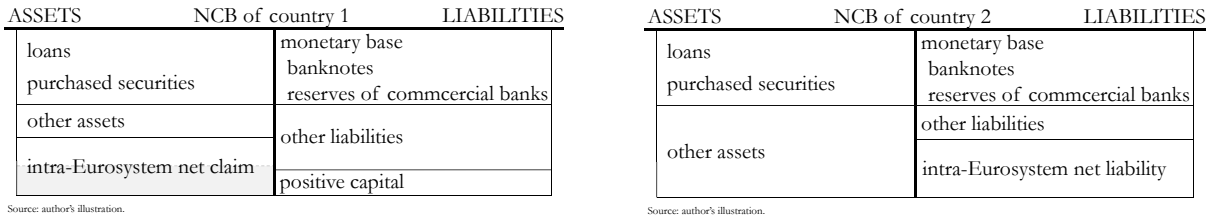
This example reveals how partial write-offs of intra-Eurosystem claims may already weaken central bank finances, which is relevant owing to the magnitude of intra-Eurosystem imbalances relative to central bank capital and risk cushion (see Section 7.2). In the following, it is discussed

[324] See e.g. Sinn 2014a,b, Whelan 2014a and Sinn 2015b for discussions and calculations of different scenarios of government default and exits of the Eurozone.

[325] Accordingly, the implicit assumption is made that the other NCBs have a zero intra-Eurosystem claim and liability, respectively.

[326] The balance sheets in Figure 7.16 are extended in comparison to that given in Figure 7.5 by "other assets" and "other liabilities". Other central bank assets are e.g. foreign exchange reserves as well as gold while other liabilities are e.g. non-monetary liabilities such as central bank securities.

Figure 7.16: Stylized central bank balance sheet with intra-Eurosystem claim/liability



how the central bank could strive for recapitalization in case of weakened finances, thus adversely affecting the government budget.

7.4 Central Bank Finances and Central Bank Recapitalization

The relaxation of collateral criteria implied risk to central bank interest income from money creation (Section 7.3.1), which is reinforced by the adverse selection of collateral. Moreover, the relaxation of collateral criteria facilitated the accumulation of intra-Eurosystem imbalances, which augment the risk of potential write-offs (Section 7.3.3). Despite the relaxation of collateral criteria, a lack of eligible collateral can lead to NCBs providing ELA to distressed banks against the collateral of even lower quality, which intensifies risk to interest income from money creation (Section 7.3.2). These three risks to the central bank balance sheet could—individually or jointly—trigger a shock to central bank finances. In the first-best scenario, the shock does not materialize. If the shock materialized and the balance sheet was impaired, central bank capital would vanish. In this case, the central bank could either operate with zero or negative capital and withstand potential adverse consequences or strive for rebuilding capital.[327] The central bank can boost its finances in two ways:[328] on the one hand, it can retain income to bolster its capital, referred to as *internal* recapitalization; and on the other, it can ask the government for support in terms of *external* recapitalization.[329] Moreover, the shock could be diverted from the central bank balance sheet and assumed by a third party ("circumvented recapitalization").

7.4.1 Internal Recapitalization

Thus far, the analysis has implicitly assumed that the central bank transfers the entirety of its income from money creation to the government. However, the transfer may fall short of total income as central banks usually retain some fraction of income, e.g. for the accumulation of capital and a risk cushion (see Section 7.1). Retention may be particularly high when central bank finances are distressed and the central bank aims to bolster capital via internal recapital-

[327] Martínez-Resano 2004 cherishes that adequate central bank capital is paramount for effective central bank independence and ultimately monetary stability. See also Section 7.1 for the importance of central bank capital.

[328] See Vaez-Zadeh 1991 and Lehmbecker 2009 for overviews of remedies for central bank losses. The central bank could also lower its operating cost which are however bounded to zero.

[329] Of course, external and internal recapitalization may take place jointly. Qualitative effects would be equivalent, i.e. a negative shock to the government budget, such that separate examination simplifies the analysis without loss of generality.

ization. The retention of central bank income when abstracting from sources other than money creation can be expressed as

$$\delta_{as} = \Gamma + \nu, \tag{7.39}$$

with Γ being the transfer from the central bank to the government (see Chapter 6) and ν the part of central bank income that is retained. Thus far, it has been implicitly assumed that $\nu = 0$ such that $\delta_{as} = \Gamma$, i.e. total seignorage was transferred to the government. In case of internal recapitalization, the central bank transfers the amount Γ_{int} that is smaller than the initial transfer Γ (i.e. without retention) and retains income to the amount of

$$\nu = \delta_{as} - \Gamma_{int} \geq 0. \tag{7.40}$$

How the transfer from the central bank to the government (and hence income retention) is determined varies across countries as distribution rules for central bank income differ. Hawkins 2003 summarizes that distribution can be laid down in *(i)* law/statute, it can be at *(ii)* the discretion of the central bank or *(iii)* the government or subject to *(iv)* negotiation between the central bank and the government. Most central banks transfer more than half of their profits to the government (ibid., Kurtzig and Mander 2003, Stella 2005).[330] Vice versa, central banks retain about half of their profits to bolster financial strength.

However, internal recapitalization is associated with three flaws. First, it may be beyond power of the central bank when profit retention is prohibited by law. Second, the bolstering of central bank capital via profit retention can be too slow as it takes place gradually. According to e.g. Marshall 2003, the restoration of a central bank balance sheet could last several decades. While this may be adequate in some cases, it may be insufficient if central bank financial weakness is pressing. Finally, financial means that are available for internal recapitalization may be restricted either explicitly by law or implicitly by the central bank's inflation target (Stella 1997, Sims 2005, Cukierman 2011, Del Negro and Sims 2014).[331] According to Lönnberg and Stella 2008, inflationary pressure from extending the monetary base to generate additional income could render the central bank "policy insolvent", i.e. it can only assure long-run profitability by increasing the monetary base at a rate inconsistent with the inflation target. Hence, the central bank may find itself in the paradoxical situation in which it tries to reestablish credibility by strengthening its financial position while undermining credibility owing to induced inflationary pressure (Goodfriend 2007). Stella 1997 argues that the central bank could offset the inflationary pressure by offering assets from its own portfolio bearing a market return in exchange for base money. However, such sterilization would balance additional income and could be restricted by central bank's supply of liquid assets. Moreover, the central bank could

[330] In a survey of 44 central banks' accounting practices, Kurtzig and Mander 2003 find that central banks transferred from 0% to more than 60% of profits to the government. Moreover, the authors claim that an increasing number of central banks predetermine declarable profits to support government revenue.

[331] Del Negro and Sims 2014 develop a model in which central bank's inflation objectives and the behavior of interest income under high inflation are crucial in determining whether the central bank can finance itself via higher interest income or if it is in need of external recapitalization. Hence, there are clear limits to the central bank's ability to credibly commit to an inflation target in the absence of a fiscal anchor for the central bank, as shown in Sims 2005.

issue own debt instruments, although this would put it at risk of accumulating unsustainable debt.

7.4.2 External Recapitalization

Let financial resources available for internal recapitalization be (explicitly or implicitly) restricted to $\bar{\nu}$ while resources necessary to restore central bank finances amount to ν_{req}. The central bank has to ask for government support if $\bar{\nu} < \nu_{req}$, i.e. if the income that the central bank could retain would be insufficient. In this case, the government is expected (but is usually not legally obliged) to provide support, which gives rise to a contingent implicit liability.[332] If the contingent implicit liability is called, the government can meet it by diverting existing funds or issuing additional government debt. In both cases, external recapitalization would result in a transfer from the government to the central bank such that central bank holdings of government debt increase (Ize 2005). However, external recapitalization is associated with shortcomings (see Stella 2005). It is related to loss of central bank independence, i.e. the central bank becomes reliant on the government.[333] Cukierman 2011 argues that maintaining a sufficiently high level of capital is essentially a (partial) insurance against states of nature in which the central bank's ability to resist the pressure of political authorities is weakened. The author asserts that the relation between central bank independence and the level of central bank capital is likely to be discontinuous in the sense that below a certain threshold of negative capital, the central bank will be seriously limited by the government. Furthermore, there is usually no legal obligation for the government to cover losses of the central bank, despite legal provisions for how central bank income is allocated between the central bank and the government.[334] Irrespective of legal obligations for the government to cover losses, the government's ability to do so, especially on a timely basis, is called into question by e.g. Stella 1997, 2005, Lönnberg and Stella 2008. The government's ability could also be limited by complex budgetary procedures that restrict discretion to provide means to the central bank and the potential coincidence of states of the world in which central bank finances are in distress with those of fiscal distress.

7.4.3 Circumvented Recapitalization

A third, less obvious form of recapitalization is one in which potential losses do not affect the central bank balance sheet as they are assumed by a third party, e.g. a supranational institution. Such circumvented recapitalization took place in the Eurozone, whereby financial means of fiscal rescue packages in e.g. Greece and Ireland were used to redeem refinancing loans, which reduced the exposure of the Eurosystem (Sinn 2015a). Furthermore, an intergovernmental

[332] For instance, Article 33.2 of the Statute does not consider external recapitalization of the ECB (ECB 2012e).

[333] See among others Stella 1997, Buiter 2008b, Lönnberg and Stella 2008, Cukierman 2011, Papi 2011 as well as Hall and Reis 2015. See Berger et al. 2001 for a survey.

[334] See Hawkins 2003 as well as Lönnberg and Stella 2008 for overviews of legal treatments of central bank profits and losses. ibid. examines data on 135 central bank laws with respect to central bank recapitalization provisions. The authors show that even in cases in which the government is legally obliged to maintain central bank finances, it may do so in a purely cosmetic fashion. Vaez-Zadeh 1991 criticizes the lack of arrangements with respect to central bank losses, which are thus often ignored until the sheer size of the problem renders ignoring it impossible.

rescue package worth EUR 10 bn was jointly provided by the European Stability Mechanism (ESM) and the IMF to Cyprus in April 2013. The aim of this rescue package was to protect the Eurosystem from write-off losses on ELA granted by the Central Bank of Cyprus to the already-insolvent Laiki Bank (see Sinn 2014a,b). While this may quantitatively alter the sharing of losses by governments, qualitative effects remain unchanged if a supranational institution backed by one or a multitude of governments assumes risks and diverts the potential shock from the central bank balance sheet, i.e. the government has to ultimately bear the cost.

7.5 Optimal Level of Collateral Criteria from a Fiscal Perspective

Collateral criteria bear a fiscal implication via their effect on central bank finances. Strict criteria imply low risk and stable income from money creation. For the Eurosystem, strict collateral criteria also hamper the accumulation of large Target balances and implicitly specify relatively strict collateral criteria for ELA. By contrast, loose criteria give rise to higher risk and unstable income with adverse effects on central bank finances. Potential adverse effects are fostered for the Eurosystem as loose collateral criteria facilitate the accumulation of large Target balances and imply loose collateral criteria for ELA. Therefore, the relaxation of collateral criteria amplifies the likelihood that the central bank calls for financial support, which would impair the government budget, irrespective of whether central bank recapitalization is internal, external or circumvented. The following elaborates on the fiscal implication of collateral criteria via their effect on central bank finances by deriving the optimal level of collateral criteria from a fiscal perspective, i.e. the fiscally desired level of collateral criteria.[335,336]

The fiscally desired level of collateral criteria is characterized as the solution to the trade-off between two opposing effects that amendments to collateral criteria bear on the government budget. On the one hand, a relaxation of collateral criteria affects the interest rate on government debt (Section 6.5.1), while on the other hand it impinges on central bank bailout (Sections 6.5.2, 7.3, 7.4). Consider a relaxation of collateral criteria in terms of a lowering of the minimum credit rating threshold $\hat{q}$.[337] First, this would lower the interest rate on government debt. Relaxed collateral criteria free up collateral that banks can use to draw additional refinancing loans from the central bank (as observed for the Eurosystem e.g. in early 2012, see Sections 2.3 and 6.5.1). The more collateral that is freed up, the more additional refinancing loans can be drawn. Additional liquidity is (at least partially) invested in government bonds, whereby this increased

[335] Of course, the fiscal perspective on central bank collateral criteria is only one of many as collateral criteria can also be considered in terms of monetary policy transmission and financial stability (Bindseil 2014). However, the fiscal perspective must not be left out of consideration as central bank collateral criteria are first and foremost a means of risk mitigation to the central bank, the finances of which are closely intertwined with the government budget.

[336] Consideration of this fiscal implication of collateral criteria acknowledges the partial regime shift from monetary dominance to a (non-Ricardian) regime of quasi-fiscal dominance observable in the Eurozone, whereby the Eurosystem became a major crisis manager (Chapter 2 and Section 6.2). Monetary dominance would imply that the central bank ignores the fiscal implication of collateral criteria on the government budget.

[337] Accordingly, collateral criteria are approached in terms of credit quality, i.e. q. Likewise, they could be interpreted in terms of e.g. liquidity.

demand drives up the bond price and lowers the interest rate and government's borrowing cost ("borrowing cost effect"), i.e.[338]

$$i \equiv i(\hat{q}), \tag{7.41}$$

with $\partial i/\partial \hat{q} > 0, \partial^2 i/\partial \hat{q}^2 > 0, \partial^3 i/\partial \hat{q}^3 = 0$. The interest rate i positively depends on $\hat{q}$ and this effect is assumed to be convex. Accordingly, the initial lowering of $\hat{q}$ would reduce the interest rate to a larger extent than any further lowering as it would free up more eligible assets.[339] Second, the previous sections addressed in detail the notion that a relaxation of collateral criteria increases the likelihood of central bank bailout ("bailout cost effect"). Central bank bailout is considered in terms of a one-time contingent implicit liability to the government, i.e. the Treasury has to divert resources to the amount of c^i to the central bank with probability

$$p^i_\lambda \equiv p^i_\lambda(\hat{q}). \tag{7.42}$$

The probability p^i_λ negatively depends on $\hat{q}$, i.e. a lower $\hat{q}$ increases the likelihood that the government has to bail out the central bank such that $\partial p^i_\lambda/\partial \hat{q} < 0$ with $\partial^2 p^i_\lambda/\partial \hat{q}^2 > 0, \partial^3 p^i_\lambda/\partial \hat{q}^3 = 0$. Hence, the likelihood is assumed to grow overproportionally with a lower $\hat{q}$, i.e. the initial lowering of $\hat{q}$ only slightly increases p^i_λ but any further lowering leads to an overproportional increase as central bank finances are further impaired owing to imperfect risk control and the adverse selection of collateral. Moreover, the better the risk control, the lower runs p^i_λ (and $\partial p^i_\lambda/\partial \hat{q}$) as additional collateral risk from lowering collateral criteria is hedged to a larger extent, which makes central bank bailout less likely. According to Section 6.4, the expected value of the contingent implicit liability of central bank bailout reads as

$$\mathbb{E}[c^i] = p^i_\lambda(\hat{q})c^i. \tag{7.43}$$

Taking into account the two opposing effects of an amendment to collateral criteria, the primary balance that ensures fiscal sustainability hitherto given by Equation (6.18) reads as[340]

$$pb = i(\hat{q})d + p^i_\lambda(\hat{q})c^i. \tag{7.44}$$

The remainder of this section characterizes the fiscally desired level of collateral criteria based on Equation (7.44) in two different environments, i.e. *(i)* one with one country and one central bank and *(ii)* one with two countries and one central bank (as a stylized form of monetary union).

[338] See Acharya and Steffen 2015 and Asonuma et al. 2015 on the negative relationship between domestic government bond holdings and government borrowing cost. See e.g. Cruces and Trebesch 2013 as well as Chamon et al. 2014 on determinants of government borrowing cost.

[339] Figure 4.6 provides anecdotal evidence on the distribution of marketable assets according to credit quality. Compare the hypothetical scenario in which the Eurosystem would lower the minimum credit rating threshold first from "A-" to "BBB+" and subsequently from "BBB+" to "BBB". Given that the first lowering would free up more eligible assets than the second lowering, the alleviating effect of the lowering on the interest rate would be stronger for the initial amendment.

[340] It is abstracted from any positive transfer from the central bank to the government, i.e. $\gamma = 0$. Moreover, economic growth and inflation are neglected, which simplifies the analysis along two dimensions: first, the real interest rate is approximately equal to the nominal interest rate; and second, potential crowding-out of private investment, which would affect economic growth, can be ignored.

7.5.1 Fiscally Desired Level of Collateral Criteria with *One* Country and One Central Bank

First, the fiscally desired level of collateral criteria is examined in the institutional setting with one country and one central bank, i.e. there is one country, whose Treasury backs the central bank. This setting resembles the situation that prevailed e.g. in Eurozone countries prior to the introduction of the euro. Moreover, it would describe the situation of the Eurozone as a fiscal union in which the common Treasury backs the common central bank. The fiscally desired level of collateral criteria evolves from balancing the two opposing effects of an amendment to $\hat{q}$. It is given by

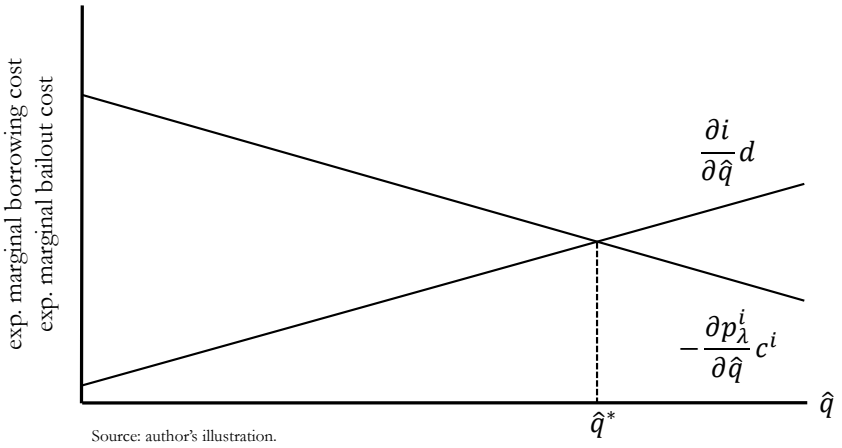
$$\hat{q}^* = \arg\min_{\hat{q}} pb(\hat{q}). \tag{7.45}$$

$\hat{q}^*$ is the credit rating threshold that minimizes the primary balance that has to be generated to keep fiscal policy sustainable. Hence, the central bank is assumed to support the government in fulfilling its present-value budget constraint (PVBC), which implies a deviation from the Ricardian regime of monetary dominance towards a (non-Ricardian) regime of (quasi-) fiscal dominance (Section 6.2). The optimal solution $\hat{q}^*$ to the trade-off is characterized by

$$\underbrace{\frac{\partial i}{\partial \hat{q}^*} d}_{\text{exp. marginal borrowing cost}} = -\overbrace{\frac{\partial p^i_\lambda}{\partial \hat{q}^*} c^i}^{\text{exp. marginal bailout cost}} \tag{7.46}$$

and is visualized in Figure 7.17. In the optimum, the level of collateral criteria balances the expected marginal borrowing cost of amending $\hat{q}$ to the expected marginal bailout cost of doing so and the minimum primary balance that ensures the sustainability of fiscal policy is implemented.[341] Therefore, the central bank can amend collateral criteria to affect the fiscal position.

Figure 7.17: Fiscally desired level of collateral criteria: one country and one central bank



Source: author's illustration.

[341] For the given functional forms, $\hat{q}^*$ is unique.

7.5.2 Fiscally Desired Levels of Collateral Criteria with *Two* Countries and One Central Bank

Second, the institutional setting is analyzed in which two countries delegate monetary policy to a common central bank, i.e. the central bank implements a level of collateral criteria in terms of a minimum credit rating $\hat{q}$ that is uniform across both countries. Divergent preferences over the level of collateral criteria from a fiscal perspective emerge in such an environment for two reasons. On the one hand, countries are considered heterogeneous with respect to their debt level, which implies different interest rates that they have to pay on their debt. On the other hand, the countries contribute asymmetrically to potential central bank bailout. This situation resembles a stylized form of the current Eurozone in which countries are heterogeneous with respect to their fiscal positions and would share central bank bailout costs unequally. The fiscal implication of collateral criteria differs for the two countries depending on the uniform level of $\hat{q}$ implemented by the common central bank. For the Treasury of country $l \in \{1, 2\}$, the individually optimal level of collateral criteria is determined by $\hat{q}_l^* = \arg\min_{\hat{q}} pb_l(\hat{q})$, which gives

$$\frac{\partial i_l}{\partial \hat{q}_l^*} d_l = -\frac{\partial p_\lambda^i}{\partial \hat{q}_l^*} k_l c^i, \tag{7.47}$$

with k_l being the country-specific share according to which the Treasury of country l would have to contribute to the bailout of the common central bank.[342] The fiscally desired level of collateral criteria can differ across countries owing to differences in

i) the expected marginal borrowing cost: the expected marginal borrowing cost given on the left-hand side of Equation (7.47) differs across countries owing to differences in the interest rate (i_l) and debt ratio (d_l);

ii) the expected marginal bailout cost: the expected marginal bailout cost reflected on the right-hand side of Equation (7.47) differs across countries owing to different contributions to central bank bailout (k_l).

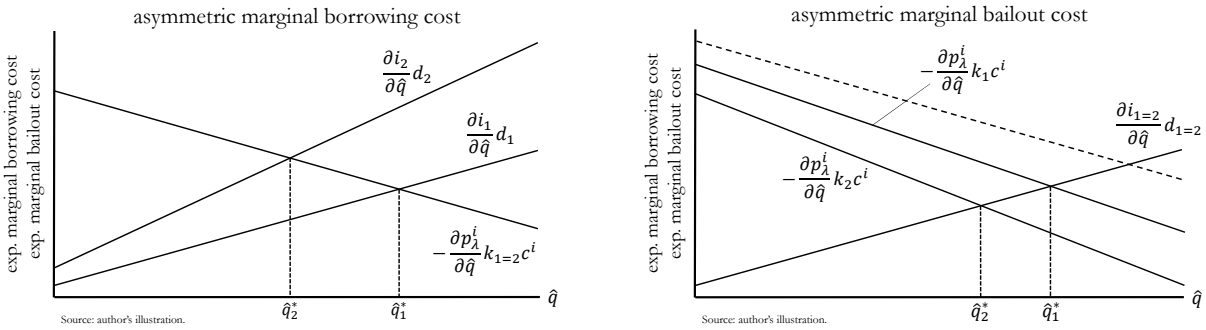
Asymmetric Marginal Borrowing Cost The two countries are asymmetrically affected by amendments to collateral criteria when they feature distinct fiscal situations (captured by the debt ratio and the interest rate). This is exemplified for the case in which country 2 bears a higher debt ratio and a higher interest rate than country 1 such that $\frac{\partial i_1}{\partial \hat{q}} d_1 < \frac{\partial i_2}{\partial \hat{q}} d_2$ for any given $\hat{q}$. For $k_1 = k_2$, the left-hand side of Equation (7.47) differs for the two countries, which implies $\hat{q}_1^* \neq \hat{q}_2^*$. The left panel of Figure 7.18 illustrates that in this case the Treasury of country 2 prefers a lower level of collateral criteria than the Treasury of country 1. Consider the case in which the fiscal situation in both countries is initially equal and corresponds to that of country 1 in the left panel of Figure 7.18. Subsequently, country 2 experiences a shock to its fiscal position, which shifts expected marginal borrowing cost upwards for any level of $\hat{q}$. In this case, the initial level of collateral criteria given by $\hat{q}_1^*$ is no longer optimal for country 2 as the expected marginal borrowing costs exceed the expected marginal bailout costs. When $\hat{q}$ is relaxed, the expected

[342] For the Eurosystem, k_l can be interpreted as the capital key of an NCB, i.e. the fraction according to which it contributed to ECB capital, with $\sum_l k_l = 1$. In the two-country setting, $k_1 + k_2 = 1$.

marginal borrowing costs decrease while the expected marginal bailout costs increase until $\hat{q}_2^*$ is characterized by $\frac{\partial i_2}{\partial \hat{q}_2^*} d_2 = -\frac{\partial p_\lambda^i}{\partial \hat{q}_2^*} k_{1=2} c^i$ in the optimum. This level of collateral criteria now desired by the Treasury of country 2 is lower than the initial level, which is still desired by the Treasury of country 1, i.e. $\hat{q}_2^* < \hat{q}_1^*$.

Asymmetric Marginal Bailout Cost Divergent preferences over $\hat{q}$ may also originate from differences in the expected marginal bailout cost of amending collateral criteria. A bailout of the common central bank constitutes a joint contingent implicit liability to the Treasuries, i.e. the Treasuries share the risk of central bank bailout. The expected marginal bailout costs from amending $\hat{q}$ are equal to both Treasuries when they are liable for the bailout in equal shares. In this case, both Treasuries would ceteris paribus prefer the same level of $\hat{q}$. However, if the Treasuries did not share bailout costs equally, the Treasury bearing the smaller cost would ceteris paribus prefer a lower level of $\hat{q}$. While this Treasury fully enjoys the benefits of lower collateral criteria, it underproportionally contributes to a potential bailout.[343] This situation is illustrated in the right panel of Figure 7.18, with the Treasury of country 2 contributing less to potential bailout than the Treasury of country 1, i.e. $k_1 > k_2$. Both Treasuries prefer a lower level of collateral criteria compared to the situation in which they would bear the entire cost (characterized by the intersection of $\frac{\partial i_{1=2}}{\partial \hat{q}} d_{1=2}$ and the dotted line). For this level of $\hat{q}$ but with sharing of bailout costs, the expected marginal borrowing costs would exceed the expected marginal bailout costs for both Treasuries, i.e. $\frac{\partial i_{1=2}}{\partial \hat{q}} d_{1=2} > \frac{\partial p_\lambda^i}{\partial \hat{q}} k_l c^i$. Optimality is achieved by trading off the expected marginal borrowing costs and expected marginal bailout costs, i.e. by lowering $\hat{q}$ down to $\frac{\partial i_{1=2}}{\partial \hat{q}_l^*} d_{1=2} = \frac{\partial p_\lambda^i}{\partial \hat{q}_l^*} k_l c^i$ with $\hat{q}_1^* > \hat{q}_2^*$. The intuition is straightforward. Although central bank bailout is a joint contingent implicit liability, Treasuries are asymmetrically liable. The beneficial effect of a lower level of collateral criteria in terms of lower interest payments on government debt is fully enjoyed by each Treasury at asymmetric costs. It is optimal for the Treasury of country 2 to prefer a lower level of collateral criteria while the Treasury of country 1 prefers a higher level, implying a lower probability of central bank bailout.

Figure 7.18: Fiscally desired levels of collateral criteria: two countries and one central bank

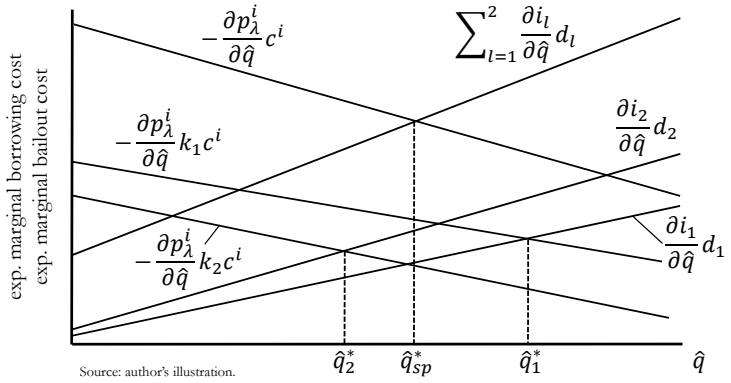


The extent of risk-sharing among countries depends on $\hat{q}$, i.e. the uniform level of collateral criteria implemented by the central bank. The stricter $\hat{q}$, the smaller the extent of risk-sharing. Figure 7.19 illustrates the extent of risk-sharing among two countries with distinct fiscal positions

[343] See Sinn 2014b for another description of this externality.

and asymmetric sharing of central bank bailout cost for three levels of collateral criteria. In the first case, the central bank chooses $\hat{q}_1^*$ as the uniform level such that the extent of risk-sharing is rather small. In the second case, the central bank implements $\hat{q}_2^*$ and risk-sharing is extended. The third case represents a situation in which the central bank implements the level of collateral criteria that a social planner with utilitarian preferences would choose from a fiscal perspective, i.e. the social planner solves $\hat{q}_{sp}^* = \arg\min_{\hat{q}} \sum_l pb_l(\hat{q})$.[344] This optimal level of collateral criteria $\hat{q}_{sp}^*$ is characterized by $\sum_l \frac{\partial i_l}{\partial \hat{q}_{sp}^*} d_l = -\frac{\partial p_\lambda^i}{\partial \hat{q}_{sp}^*} c^i$, i.e. total expected marginal borrowing costs are balanced to total expected marginal bailout costs in the optimum. Figure 7.19 shows that $\hat{q}_{sp}^*$ is in between $\hat{q}_1^*$ and $\hat{q}_2^*$ and the extent of risk-sharing is mediocre as it is larger than for $\hat{q}_1^*$ but smaller than for $\hat{q}_2^*$.

Figure 7.19: Uniform level of collateral criteria and extent of risk-sharing



In this context, the fiscal implication of collateral criteria originates from the effect of the uniform level $\hat{q}$ on the sustainability-ensuring primary balance pb_l for $l = \{1, 2\}$. This primary balance is given for both Treasuries and the three addressed levels of $\hat{q}$ in Table 7.1: *(i)* the level preferred by the Treasury of country 1, i.e. $\hat{q}_1^*$; *(ii)* the level preferred by the Treasury of country 2, i.e. $\hat{q}_2^*$; and *(iii)* the level that the social planner would prefer, i.e. $\hat{q}_{sp}^*$ with $\hat{q}_2^* < \hat{q}_{sp}^* < \hat{q}_1^*$. The last column seizes upon the fiscal implication of collateral criteria by comparing the sustainability-ensuring primary balance pb_l for the two countries and the three possible levels of collateral criteria. The table indicates that each Treasury would have to generate the lowest primary balance if the central bank implemented the optimal level of collateral criteria for the respective Treasury. By contrast, if the central bank implemented the level preferred by the respective other Treasury, both Treasuries would have to generate the highest primary balance. If the central bank chose the social-planner level, collateral criteria would be too lax for the Treasury of country 1 and too strict for that of country 2. Accordingly, the central bank can enforce risk-sharing and transfer fiscal sustainability across countries depending on the initial level of $\hat{q}$. The relaxation of collateral criteria from $\hat{q}_1^*$ to $\hat{q}_{sp}^*$ would increase risk-sharing and transfer fiscal sustainability from country 1 to country 2 since the sustainability-ensuring primary balance decreases in country 2 but increases in 1. Analogously, an increase in collateral criteria from

[344] Note that the case with a social planner differs from that with a fiscal union between the countries, whereby a single fiscal authority would back the central bank in the latter case. Accordingly, the case of fiscal union would resemble the situation with one country and one central bank described in Section 7.5.1. See Bordo et al. 2011, Fuest and Peichl 2012, Dolls et al. 2014 for further information on fiscal integration and fiscal union in the context of the Eurozone.

$\hat{q}_2^*$ to $\hat{q}_{sp}^*$ would reduce risk-sharing and transfer fiscal sustainability from country 2 to country 1. This illustrates how collateral criteria can be used as a means to affect fiscal positions and transfer fiscal sustainability across countries. In a monetary union of heterogeneous countries, the central bank can improve the fiscal situation of one country at the expense of another via the choice of the level of collateral criteria.

Table 7.1: Fiscal implications of different levels of $\hat{q}$

l	$\hat{q}_1^*$	$\hat{q}_2^*$	$\hat{q}_{sp}^*$	Fiscal Implication
1	$pb_1(\hat{q}_1^*)$	$pb_1(\hat{q}_2^*)$	$pb_1(\hat{q}_{sp}^*)$	$pb_1(\hat{q}_1^*) < pb_1(\hat{q}_{sp}^*) < pb_1(\hat{q}_2^*)$
2	$pb_2(\hat{q}_1^*)$	$pb_2(\hat{q}_2^*)$	$pb_2(\hat{q}_{sp}^*)$	$pb_2(\hat{q}_2^*) < pb_2(\hat{q}_{sp}^*) < pb_2(\hat{q}_1^*)$

Source: author's compilation.

Interpretation for the Eurozone

The Eurosystem defined uniform collateral criteria with the introduction of the Single List in January 2007 (Section 3.1). Section 3.2 revealed that uniform collateral criteria were relaxed and that the Eurosystem deviated from uniformity after the onset of the financial crisis. The financial crisis also triggered substantial increases in the debt ratios of Eurozone countries, culimating in the sovereign debt crisis. Interest rates that Eurozone governments had to pay on their debt converged prior to but spread during the sovereign debt crisis (e.g. Sinn 2012, 2014b). Within the simple technical framework, the sovereign debt crisis induced a shock to borrowing costs, which differed across countries and induced asymmetric changes to levels of collateral criteria preferred from a fiscal perspective. Different preferences were amplified by disparate contribution rates to central bank bailout (cf. right panel of Figure 7.18) in the Eurosystem. Some countries suffering from the largest surge in their debt ratio and interest rate were among those that would have only had to contribute little to a central bank bailout.

Fiscally desired levels of collateral criteria for selected Eurozone countries are stylized in Equation (7.48). The fraction on the right-hand side of Equation (7.48) implicitly characterizes desired levels based on Equation (7.47) in terms of k_l and d_l. c^i is considered equal to unity for simplicity but without loss of generality:

$$-\frac{\partial i_l/\partial \hat{q}_l^*}{\partial p_\lambda^i/\partial \hat{q}_l^*} = \frac{k_l}{d_l}. \tag{7.48}$$

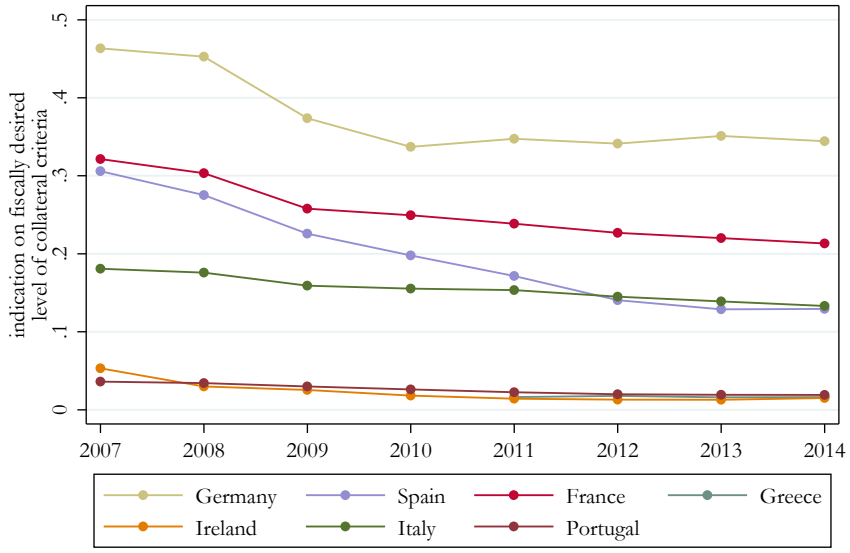
As, ceteris paribus, a large k_l and/or a small d_l implies a preference for strict collateral criteria, countries with large k_l/d_l prefer strict collateral criteria while countries with low k_l/d_l desire loose collateral criteria. The development of the implicitly characterized fiscally preferred level of collateral criteria is stylized in Figure 7.20 for selected Eurozone countries from 2007 to 2014. It suggests substantial differences in preferences and that preferences varied slightly from 2007 to 2014. As k_l remained relatively stable,[345] variations in preferences were driven by

[345] Paid-up shares changed five times but only slightly in January 2008 (Cyprus and Malta joined EMU), January 2009 (Slovakia joined EMU), January 2011 (Estonia joined EMU), July 2013 (Croatia joined EU) and January 2014 (Latvia joined EMU).

asymmetric developments in public indebtedness. The figure indicates that Germany preferred the strictest collateral criteria, while Greece, Ireland and Portugal had a preference for loose collateral criteria.

Figure 7.20: Indication on the fiscally preferred level of collateral criteria in selected countries

The figure seizes upon the development of fiscally preferred levels of collateral criteria by detailing the evolution of preferences implicitly characterized by Equation (7.48). Countries with large values tend to prefer relatively strict collateral criteria, while those with low values desire relatively loose collateral criteria. It suggests differences in preferences across countries, which varied slightly from 2007 to 2014.



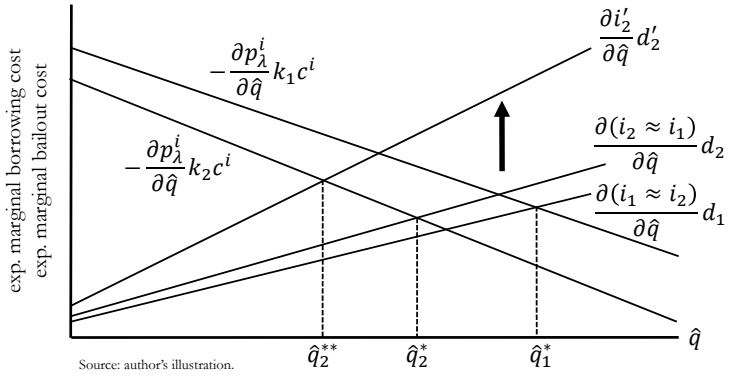
Greece: 2011-2014.
Source: author's calculation; European Central Bank; Eurostat.

The intuition can be exemplified by a comparison of the indicators for Germany and Portugal. The indicator was 0.46 for Germany and 0.036 for Portugal in 2007. As both countries had comparable debt ratios at that time (63.7% in Germany and 68.4% in Portugal), differences in the contribution to a potential central bank bailout accounted for the substantial difference in the implicitly characterized preference over the level of collateral criteria: while Germany would have had to pay 29.52% of such a bailout, Portugal would have only had to contribute 2.47%. By the end of 2014, the implicitly characterized preference decreased to 0.34 in Germany and 0.019 in Portugal. Although the contribution rate for Germany dropped to 25.72% in 2014 while it remained relatively stable in Portugal (2.49%), the development is attributed to asymmetric evolutions of fiscal positions, given that the debt ratio increased by 11 percentage points (74.7% in 2014) in Germany and surged by 61.8 percentage points (130.2% in 2014) in Portugal.

The effects of asymmetric developments in fiscal situations in Germany and Portugal on $\hat{q}_l^*$ are stylized in Figure 7.21. Initially, expected marginal borrowing costs were almost identical for country 1 (Germany) and country 2 (Portugal) as interest rates were approximately equal ($i_1 \approx i_2$ owing to interest-rate convergence prior to the crisis, cf. Sinn 2012, 2014b), while the debt ratios only slightly differed ($d_1 < d_2$). However, the expected marginal bailout costs differed as both countries would have had to contribute to a central bank bailout to differing extents ($k_1 > k_2$). This implies that Portugal already preferred laxer collateral criteria than Germany prior to the crisis i.e. $\hat{q}_2^* < \hat{q}_1^*$. The crisis-induced shock to public finances ($d_2' \gg d_2, i_2' \gg i_2$)

is stylized to have hit Portugal such that the expected marginal borrowing costs were shifted upward.[346] This induced a decrease in the level of collateral criteria preferred by Portugal to $\hat{q}_2^{**} < \hat{q}_2^{*} < \hat{q}_1^{*}$. The range of fiscally desired levels of collateral criteria within which the common central bank specifies uniform criteria widens owing to the crisis-induced drop in the level preferred by Portugal. Depending on the uniform level of collateral criteria, Germany could be worse off owing to the deterioration of Portugal's fiscal position. If the central bank acted e.g. as an utilitarian social planner, a shock to the fiscal situation in country 2 would result in a lower level of uniform collateral criteria, thus implying a larger extent of risk-sharing (see above). This lower level of collateral criteria would improve the fiscal situation in country 2 at the expense of the fiscal situation in country 1. As argued above, fiscal sustainability would be transferred across countries.

Figure 7.21: Sovereign debt crisis and fiscally desired levels of collateral criteria



This qualitative discussion of the (cross-country) fiscal implication of amendments to collateral criteria has attempted to reason the observable relaxations of the Eurosystem collateral framework throughout recent years. Moreover, the investigation of divergent preferences over collateral criteria across countries exemplified for Germany and Portugal sheds light on the endeavor of several NCBs to relax collateral criteria below the uniform level. This endeavor predominantly manifested in the ACCs framework, in which the Banco de Portugal was one of seven NCBs that deemed eligible assets of quality lower than stipulated by the Eurosystem collateral framework (Section 3.2.1).

The analysis suggests that collateral criteria can serve as a tool to accommodate fiscal shocks rather than mere risk protection.[347] The immanent difference between conventional monetary policy tools such as the interest rate and collateral criteria bases on their distinct purpose. For the Eurosystem, the interest rate is a policy instrument, i.e. it does not address counterparty risk but is the same for all counterparties (Section 4.2). Counterparty risk is hedged by imposing restrictions on counterparties (see above) and by stipulating collateral. Relaxing collateral crite-

[346] The situation is assumed to have remained unchanged in Germany, where the higher debt ratio was compensated by decreases in the interest rate.

[347] See Bindseil 2013 for an assessment concerning how central banks' collateral framework can be interpreted as a policy instrument to sustain financial stability and implement monetary policy rather than as risk protection. See also Cassola and Koulischer 2014, Koulischer and Struyven 2014, Koulischer 2015 as well as Weber 2015 for elaborated approaches. Moreover, Brunnermeier 2012 proffers to use collateral policy (in terms of haircuts) to improve monetary policy in a suboptimal monetary union.

ria to accommodate fiscal shocks would alienate collateral from its primary purpose of hedging risk (on condition of ensured counterparty access) as the Eurosystem's risk exposure would increase if additional collateral risk was insufficiently addressed by haircuts. In this case, collateral criteria could be amended to accommodate fiscal shocks at the cost of lower risk protection.

8

Fiscal Implication from Collateral Criteria and Government Guarantees

The previous chapter addressed the cross-country fiscal implication of collateral criteria resulting from divergent preferences over the uniform level of collateral criteria. By contrast, this chapter elaborates on the fiscal implication of collateral criteria evolving from the close relation between collateral criteria and government guarantees to the financial sector. It shows that the Eurosystem collateral framework involves government discretion to free up new collateral by giving explicit guarantees. This shapes the government's incentive to grant explicit guarantees. It is shown that governments contributed to the provision of additional collateral, which was deemed necessary during the financial and sovereign debt crisis to accommodate collateral scarcity. Hence, the collateral framework of the Eurosystem was key to the accumulation of government guarantees, i.e. contingent explicit government liabilities, and intensified the nexus between governments and the financial sector, which is often considered vicious (Farhi and Tirole 2014, Sinn 2014b, Allen et al. 2015, Nyborg 2015). *The chapter is structured as follows. Section 8.1 elaborates how the Eurosystem collateral framework involves government discretion to create collateral. Stylized facts on government guarantees to eligible marketable assets in the Eurozone over recent years are derived in Section 8.2. Section 8.3 reviews the common rationale for government guarantees, before Section 8.4 finally presents the novel rationale that characterizes government incentives to give explicit guarantees from a fiscal perspective in due consideration of collateral criteria. This novel rationale can contribute to explain the development observable in the Eurozone of explicit government guarantees to eligible marketable assets.*

8.1 Government Discretion to Create Collateral

The Eurosystem repeatedly relaxed collateral criteria related to government-guaranteed marketable assets (Section 3.2 and in particular Figure 3.3). Most importantly, it introduced the eligibility of government-guaranteed own-use uncovered bank bonds in February 2009. This amendment is crucial as it made the eligibility of such bonds endogenous to the government, i.e. it gave the government discretion over eligibility and freeing up collateral.[348] This is particularly important under full allotment as collateral availability constitutes the de facto limit to borrowing from the Eurosystem. Furthermore, the minimum rating threshold was repeatedly suspended for assets guaranteed by governments of crisis-stricken countries.

Governments have discretion to create collateral as their guarantees can affect collateral in three ways:[349] first, the guarantee can be basal for eligibility, e.g. in case of own-use uncovered bank bonds; second, the guarantee augments the collateral value of an eligible asset when it improves the credit assessment deemed decisive for haircut determination; and third, the guarantee augments the collateral value by increasing the market value of the asset.

Therefore, the collateral framework involves discretion for governments to free up new collateral, i.e. to create eligible assets that financial institutions can pledge with the Eurosystem. Figure 8.1 indicates whether selected governments have made use of this discretion. The bars indicate the nominal value of newly guaranteed eligible assets (given on the left axis), differentiated by type of guaranteed asset. The change in refinancing credit (relative to the previous month) granted by the respective NCB is also depicted on the left axis. Moreover, the figure measures the average residual maturity of newly guaranteed eligible assets on the right axis.

The figure indicates that governments have made use of their discretion to create collateral via government guarantees to differing extents.[350] In Germany, government guarantees were predominantly given to uncovered bank bonds during the financial crisis and later to other marketable assets. The residual maturity of newly guaranteed assets fluctuated around the average of 4.08 years. The Spanish government predominantly guaranteed uncovered bank bonds with relatively low residual maturity (average residual maturity of guaranteed assets between February 2009 and December 2013: 6.65 years) as of February 2009. Moreover, Spanish government guarantees were given to ABSs prior to the financial crisis, to uncovered bank bonds during the financial crisis as well as during the period of extended liquidity provision by the Eurosystem ("big bazooka" period), and to corporate bonds in the beginning of 2013. The panel also reveals that Spanish banks extensively drew credit from the Eurosystem during the "big bazooka" period, a fraction of which was likely collateralized by guaranteed assets that feature an average residual maturity of 4.24 years (January 2012 to March 2012), i.e. slightly above

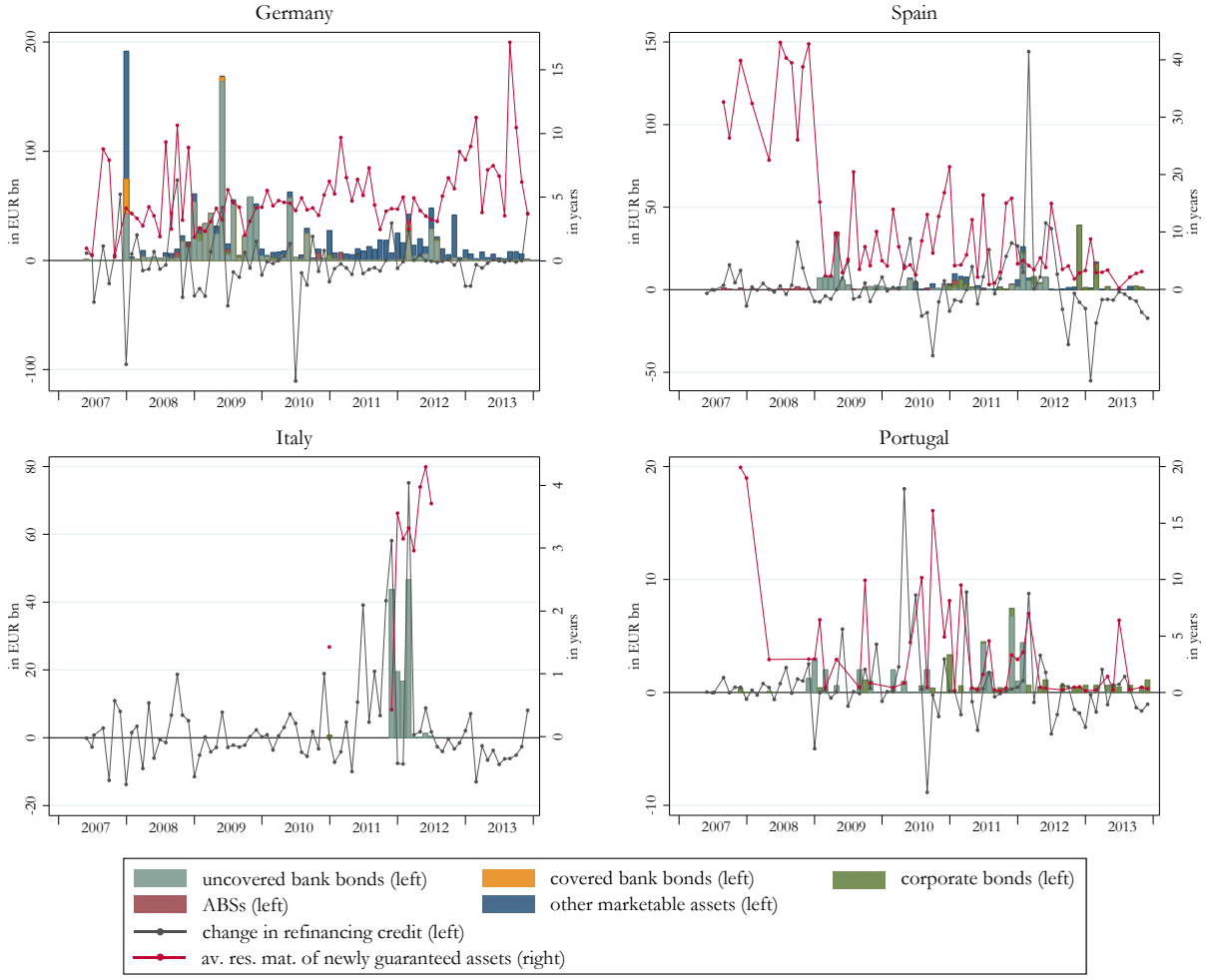
[348] The fact that a fraction of pledged uncovered bank bonds was own-use and hence only eligible in case of government guarantee can be inferred from the Eurosystem's repeated efforts to restrict their pledge (Figure 3.3).

[349] See Section 3.1.4.3 and Brendel et al. 2015 for how the Eurosystem takes government guarantees into account for the credit assessment of collateral. Moreover, Levy and Schich 2010, Levy and Zaghini 2010 as well as Davies and Ng 2011 show that the costs of issuing a guaranteed debt instrument are mainly determined by the creditworthiness of its guarantor.

[350] The notion that some governments made use of their discretion to provide collateral via guarantees is also documented in Sinn 2014b and Nyborg 2015.

Figure 8.1: New government guarantees to eligible marketable assets in selected countries

The figure indicates whether selected governments made use of the discretion to create collateral. The bars reflect the nominal value of newly guaranteed eligible assets on the left axis, differentiated by asset type. The flow of refinancing credit (relative to the previous month) granted by the respective NCB is depicted on the left axis. Moreover, the figure measures the (unweighted) average residual maturity of newly guaranteed eligible assets on the right axis. It indicates that governments made use of their discretion to create collateral via government guarantees to differing extents.



Source: author's calculation; European Central Bank, *Eligible Assets Database*.

the duration of the three-year LTROs and lower than the overall average (excluding ABSs) of 6.65 years.[351] In Italy, government guarantees were almost exclusively given to uncovered bank bonds during the "big bazooka" period. As in Spain, Italian banks extensively borrowed from the Eurosystem during this period. The panel suggests that a large portion of new refinancing credit was collateralized by uncovered bank bonds, which were newly eligible with a government guarantee.[352] With 3.18 years on average, assets guaranteed between December 2011 and July 2012 had a residual maturity almost matching the duration of the three-year LTROs. Likewise, the Portuguese government extended government guarantees to newly eligible marketable assets

[351] For this purpose, the Spanish government reintroduced the "Spanish Guarantee Scheme" in January 2012, which was initiated in October 2008, see EC 2012, "State Aid SA. 34224 (2012/N)–Spain. Reintroduction of the Spanish Guarantee Scheme," 9 February 2012.

[352] The government of Italy implemented its first guarantee scheme to the financial sector in December 2011, see Clifford Chance, "Italian Government Guarantees. Easing the Pressure on Italian Banks," *Client Briefing*, 23 December 2011.

(primarily uncovered bank bonds) during the "big bazooka" period (esp. in March 2012).[353] Between December 2011 and March 2012, the Portuguese government guaranteed newly eligible assets with average residual maturity of 4.23 years.

Further indication on whether governments made use of the discretion to create eligible collateral is corroborated by Table 8.1, which compares monthly averages of new government guarantees over the pre-"big bazooka" period (June 2006 to November 2011), the "big bazooka" period (December 2011 to March 2012) and the post-"big bazooka" period (April 2012 to December 2013) for selected countries. It shows that all governments aside from the German substantially extended guarantees during the "big bazooka" period.

Table 8.1: Monthly average value of new government guarantees in selected countries

The table compares the monthly average value of new government guarantees to eligible marketable assets for selected countries prior to, during and after the "big bazooka" of the Eurosystem. It illustrates that new government guarantees to marketable assets considerably increased in all countries except for Germany during the "big bazooka" period.

	Monthly Average (Total)[a]		
	Pre-"Big Bazooka" 06/2007 - 11/2011	"Big Bazooka" 12/2011 - 03/2012	Post-"Big Bazooka" 04/2012 - 12/2013
Germany	21.1 (1137)	15.1 (60.4)	11.1 (233.7)
Spain	2.7 (144.9)	10.7 (42.7)	4.3 (89.6)
France	2.8 (150)	16.9 (67.5)	8.5 (178.1)
Greece	1.3 (72)	4.5 (18.1)	2 (41.8)
Ireland	5 (271.5)	10.5 (42)	2.6 (53.6)
Italy	0.01 (0.8)	31.6 (126.5)	0.1 (1.9)
Portugal	0.6 (30.1)	3.4 (13.6)	0.4 (8.5)

[a] in EUR bn; deviations possible owing to rounding.
Source: author's calculation; European Central Bank, *Eligible Assets Database*.

This development of new government guarantees to eligible marketable assets suggests a close tie between central bank collateral criteria government incentive to grant explicit guarantees. This connection is further elaborated in the following.

8.2 Stylized Facts on Government Guarantees in the Eurozone[354]

Government support to the financial sector can take the form of deposit insurance, explicit and implicit guarantees as well as general guarantee schemes.[355] The present analysis focuses on explicit government guarantees to eligible marketable assets and derives two stylized facts on their development in the Eurozone from 2007 to 2013.

[353] The Portuguese government did not set up a new government guarantee scheme as the one implemented in October 2008 remained in place, see Muller et al. 2012.

[354] This section bases on Eberl and Weber 2015.

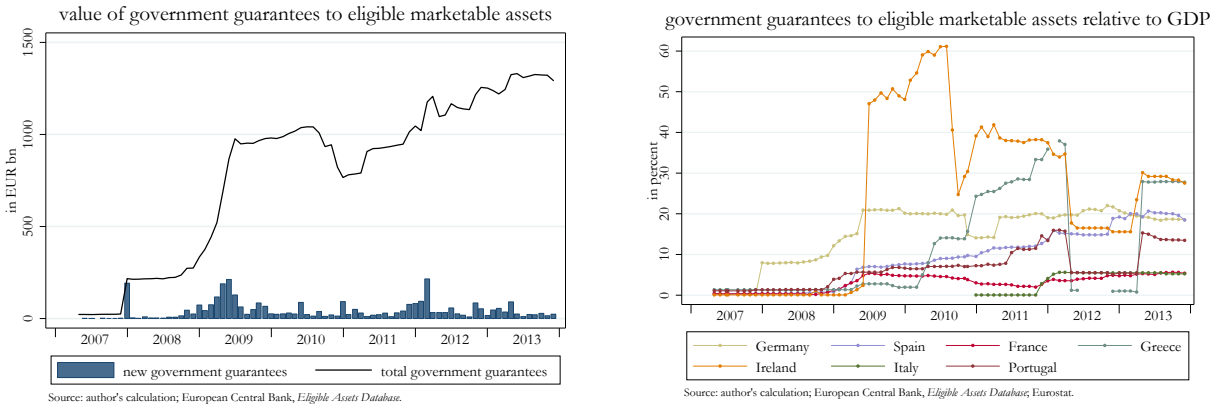
[355] On the importance of government support to the financial sector, especially in times of financial distress, see Diamond and Dybvig 1983, Gorton 1988, Jacklin and Bhattacharya 1988, Allen and Gale 1998 as well as Allen et al. 2015. See Sinn 2010a, Allen et al. 2011, Muller et al. 2012 as well as Allen et al. 2015 for government interventions in the Eurozone during the recent financial crisis. Despite its calming effect, government intervention potentially features high costs as well as moral hazard effects, see Section 6.3 and below.

Figure 8.2 seizes upon the finding of Section 3.3, namely that government guarantees to eligible marketable assets grew in importance between May 2007 and December 2013. The left panel depicts the development of the total nominal value of government-guaranteed eligible marketable assets (line) together with the nominal value of new government guarantees in each month (bars). It reveals that the value of new government guarantees substantially increased throughout 2009 and at the turn of 2011/2012.[356] This development explains the swift rise in the stock of government guarantees from EUR 22 bn in May 2007 to EUR 1293 bn in December 2013. The right panel stylizes the development of the total nominal value of government-guaranteed assets relative to GDP for selected countries, showing that the value of government guarantees relative to GDP substantially increased in all countries. For all countries except for Italy and Greece, the increase can be attributed to the onset of the financial crisis in the fall of 2008. This particularly holds for Ireland, where government guarantees to eligible assets reached 60% of GDP.[357] Government guarantees increased to about 20% of GDP in Germany as well as Spain and peaked at some 40% in Greece. In Italy, government guarantees did not play a role throughout the financial crisis and the early phase of the sovereign debt crisis. The Italian government started to guarantee eligible marketable assets as of the turn of 2011/2012 (see Section 8.1) to the amount of up to 8% of GDP.

Stylized Fact 8.1: Government guarantees grew in importance. Government guarantees to eligible marketable assets grew in importance in particular during two phases, i.e. during *(i)* the financial crisis (11/2008 to 12/2009) and during *(ii)* the phase of increased liquidity provision by the Eurosystem ("big bazooka" period, 12/2011 to 03/2012).

Figure 8.2: Government guarantees to eligible marketable assets

The left panel depicts the development of the stock of government guarantees to eligible marketable assets (line) from 2007 to 2013, together with the flow of government guarantees in each month (bars). The right panel stylizes the development of the stock of government guarantees relative to GDP for selected countries. The figure confirms the finding of Section 3.3.7 that importance of government guarantees for eligible marketable assets has increased over recent years.



Source: author's calculation; European Central Bank, *Eligible Assets Database*; Eurostat.

Considering the increased importance of government guarantees during the two periods, the remainder of this section investigates the structure of newly guaranteed eligible marketable

[356] Additionally, there was a sharp increase in guarantees in January 2008 as the German government guaranteed issuances of government-linked financial institutions.

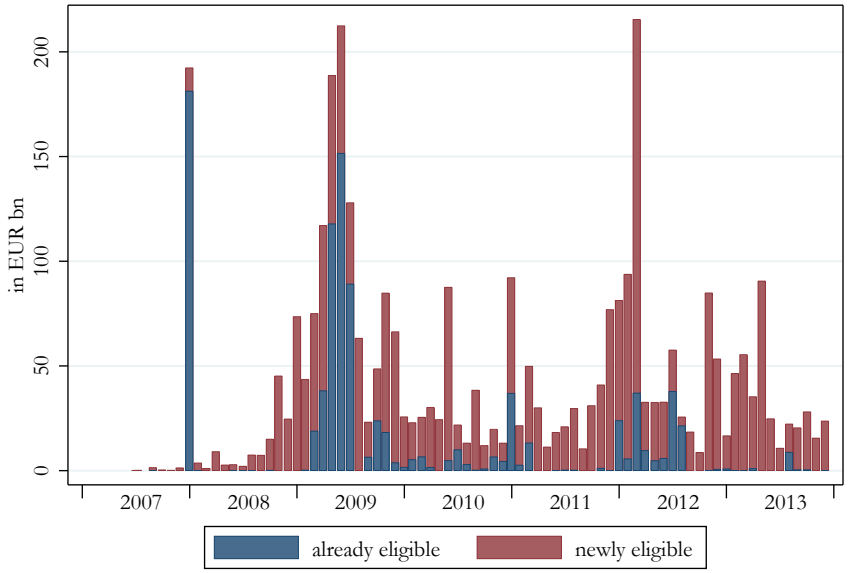
[357] This figure refers to government guarantees to marketable assets eligible with the Eurosystem. Overall, Irish government guarantees to the financial sector rose to about 200% of GDP (cf. Allen et al. 2015).

assets in terms of: *(i)* the eligibility of guaranteed assets, i.e. already vs. newly eligible assets; *(ii)* the type of guaranteed assets; and *(iii)* governments that guaranteed assets.

According to the first dimension, government guarantees can be given to *(i)* assets that were already eligible or *(ii)* assets that became newly eligible (respective or irrespective of the guarantee). This differentiation is illustrated in Figure 8.3. The figure reveals that at the outset of the financial crisis, a considerable fraction of new government guarantees was directed to already-eligible marketable assets. However, new government guarantees were predominantly granted to newly eligible assets over time and throughout the sovereign debt crisis.

Figure 8.3: Structure of new gov. guarantees: guarantees to already- vs. newly eligible assets

The figure elaborates on the blue bars in left panel of Figure 8.2 and differentiates between government guarantees to *(i)* assets that were already eligible and *(ii)* assets that became newly eligible. While a considerable fraction of new government guarantees was directed to already-eligible marketable assets at the outset of the financial crisis, new government guarantees were predominantly granted to newly eligible assets thereafter.



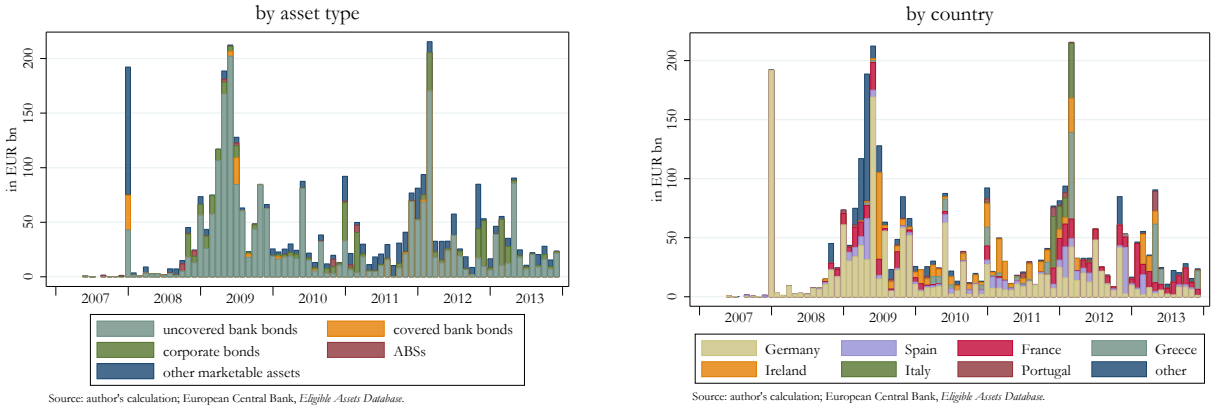
Source: author's calculation; European Central Bank, *Eligible Assets Database*.

The left panel of Figure 8.4 provides indications concerning the second dimension, i.e. the type of assets that received a new government guarantee. The panel indicates that the vast majority of guarantees were given to uncovered bank bonds. Moreover, corporate bonds and other marketable assets were substantially guaranteed, while covered bank bonds only occupied importance in January 2008 and July 2009. ABSs played a minor role for government guarantees. The right panel of Figure 8.4 provides evidence on the geographical distribution of government guarantees, revealing that the German government gave the lion's share of new guarantees prior to and throughout the financial crisis. New guarantees in considerable value were also granted by the governments of France, Ireland, Spain, Denmark and the UK (the latter two are comprised in "other") throughout 2009. During the European sovereign debt crisis, Greece and Italy also became active in granting guarantees to eligible marketable assets.

Stylized Fact 8.2: The structure of newly guaranteed assets changed. During the financial crisis, government guarantees were given to both already and newly eligible assets

Figure 8.4: Structure of new gov. guarantees: guarantees by asset type and by country

This figure further investigates the blue bars in the left panel of Figure 8.2 in terms of types of guaranteed assets (left panel) and the geographical distribution (right panel). During the beginning of the financial crisis, Germany gave new guarantees predominantly to eligible uncovered bank bonds. Throughout the European sovereign debt crisis, mainly uncovered bank bonds as well as corporate bonds and other marketable assets were guaranteed by governments of crisis-stricken countries.



Source: author's calculation; European Central Bank, *Eligible Assets Database*.

Source: author's calculation; European Central Bank, *Eligible Assets Database*.

(39% and 61% of total nominal value, respectively), which were largely uncovered bank bonds (79%), and guarantees were spread across various countries (only 14% of guarantees were granted in countries later stricken by the sovereign debt crisis). During the "big bazooka" period, new government guarantees were still predominantly granted to uncovered bank bonds (77%), although these were newly eligible (85%) and issued in crisis-stricken countries (61%) to a large extent.

8.3 Common Rationale for Government Guarantees

The common rationale for government guarantees dates back to the seminal contribution by Diamond and Dybvig 1983.[358] Government guarantees are rationalized as support to illiquid financial institutions. These institutions face a potential run on their deposits owing to panic among depositors, based on the self-fulfilling belief of deposit withdrawal. The government can intervene and provide liquidity insurance to rule out panic-driven bank runs. Accordingly, government guarantees would be a costless and fully effective means to prevent bank runs. However, this result crucially relies on three assumptions: *(i)* bank runs are solely caused by irrational panic, i.e. banks may be illiquid but solvent; *(ii)* guarantee schemes are fully credible as the government possesses sufficient financial means; and *(iii)* guarantees are costless to the government as any positive probability of bank run is ruled out by the announcement of and the commitment to the guarantee.[359]

However, the recent financial crisis suggests that these assumptions may be misleading. Bank runs may not be driven by irrational panic rather caused by deterioration of fundamentals such

[358] See e. g. Allen et al. 2015, 2011 for discussions.

[359] Moreover, Diamond and Dybvig 1983 abstract from potential moral hazard effects of guarantees (Allen et al. 2015, 2011).

as economic conditions and the value of bank assets, which gives rise to insolvencies of banks.[360] Moreover, governments experienced hard times in providing sufficient resources for necessary guarantees.[361] In this case, government guarantees cannot fully foreclose the possibility of bank runs. Under these circumstances, government guarantees *(i)* may not be fully effective in preventing the occurrence of bank runs and *(ii)* can entail substantial costs, thus rendering them *(iii)* a potential threat to the government budget.[362]

Recent literature has investigated the close link between the government budget and financial stability of the financial sector via government guarantees, see Cooper and Nikolov 2013 as well as Acharya et al. 2014b. The government is considered to have limited resources such that extended government support to the financial sector tightens the government budget. This gives rise to a feedback loop between the government and the financial sector in which any deterioration of the position of the financial sector spills over to the government and vice versa.[363] As government guarantees place pressure on the government budget, beneficiaries of the guarantee start to question the government's ability to honor it. This reduces the credibility of the guarantee and likewise its effectiveness in preventing bank runs. Consequently, instability in the financial sector increases, thus calling for further public intervention.

8.4 Novel Rationale: Importance of Collateral Criteria for Government Guarantees

When the announcement of government guarantees does not preclude the possibility of bank runs, the expected costs and benefits of a guarantee have to be taken into account. The next section presents a novel yet simple rationale for the government decision to guarantee (eligible) assets based on the trade-off between the costs and benefits from a fiscal perspective. Specifically, the approach recognizes the government as an agent with limited resources and considers the government's PVBC as the benchmark (see Section 6.4). Government guarantees are considered a powerful means to mitigate banking crisis as they can calm panic-fueled depositors. Collateral eligibility amplifies this power of government guarantees. Depending on the strictness of collateral criteria, government guarantees can have beneficial effects beyond calming depositors as they augment liquidity in the financial sector when they free up collateral. While the common rationale does not explain why the structure of guaranteed assets has changed over time, the novel rationale can expound that explicit guarantees to eligible marketable assets have gained in importance over time, as well as explaining how the structure of newly guaranteed assets developed. Moreover, while the common rationale can only rationalize government guarantees to illiquid but solvent banks, the novel rationale can also back up government guarantees to liquid banks that seek to restructure borrowing by pledging uncovered bank bonds with the

[360] See Chari and Jagannathan 1988, Jacklin and Bhattacharya 1988 as well as Allen and Gale 1998 for this fundamentals-based approach to bank runs. For a comparison of panics vs. fundamentals as the reason for bank runs, see Goldstein 2012.

[361] In general terms, Eurozone governments lack the possibility of monetizing guarantees. However, monetizing would be associated with the cost of inflation.

[362] Accounting for the possibility that government guarantees can be costly to the government also calls for an examination of the funding structure of the guarantee scheme. As the government cannot generate resources without distortions, the cost may offset any benefit.

[363] This feedback loop has intensified in recent years owing to a rise in home bias in government bond holdings (Section 6.5.1).

Eurosystem. Accordingly, this can elucidate the observable growing importance of government guarantees over recent years.

Three types of bonds that the government guarantees can be differentiated: first, bonds that are eligible irrespective of the government guarantee; second, bonds that are only eligible with the government guarantee; and third, bonds that are ineligible irrespective of the government guarantee. The government would grant guarantees to bonds of the second type if it sought to increase liquidity in the financial sector by freeing up collateral.

The approach is elaborated in three steps. First, the expected costs that accrue to the government from the guarantee are examined. It is argued that they differ between guarantees to bonds that are *(i)* ineligible and *(ii)* eligible as collateral with the central bank. Second, the benefits of the guarantee to the government are characterized, whereby it is discussed that the benefits likewise differ between guarantees given to eligible and ineligible bonds. Third, the optimal level of government guarantees is characterized by solving the trade-off between the costs and benefits of guarantees. It is shown that governments have strong incentives to guarantee eligible bonds owing to the lower expected costs and larger benefits.

8.4.1 Expected Costs of a Government Guarantee

Government guarantees on pledged assets would only be called in case of "double default", i.e. if both the counterparty and the collateral default. This is illustrated in Table 8.2, in which the independent probabilities of counterparty and collateral success are again denoted by p_L and q, respectively. When only one of the counterparty or the collateral defaults (or neither), the government does not appear on the scene and the payout is zero. The government is called upon in case of double default, which happens with probability $(1-p_L)\cdot(1-q)$. With respect to the framework of fiscal sustainability analysis, this probability is subsumed as $p^e_\lambda \equiv (1-p_L)\cdot(1-q)$, i.e. p^e_λ gives the probability that the explicit government guarantee is called and is distributed according to a Poisson process (see Section 6.4). In case of close links between the counterparty and the collateral issuer (see Section 7.3.1), the probability is given by $p^e_\lambda \equiv (1-p_L)\cdot(1-\chi)$ as the success probability of collateral χ is contingent on success of the counterparty. For own-use uncovered bank bonds, $\chi = 0$ such that $p^e_\lambda \equiv (1-p_L)$. When the guarantee is called, the government has to pay c^e if the collateral is eligible (and pledged) and $\overline{c}^e$ if the bond is ineligible with the Eurosystem but used as collateral in a private repo. The next two paragraphs argue that expected costs differ, i.e. $\mathbb{E}[\overline{c}^e] \neq \mathbb{E}[c^e]$, depending on whether the guaranteed bond is pledged as collateral in a private or public repo.

Guaranteed Bond Used as Collateral in Private Repo

Figure 8.5 illustrates the course of action for a government-guaranteed bond used as collateral in a private repo. All solid lines represent actions that take place irrespective of counterparty/collateral default. The borrower issues a bond that is guaranteed by the government and pledged in a repo with a private lender for liquidity.[364] By contrast, the dashed line depicts action by

[364] As in Chapter 5, only the opening leg of the repo is considered for simplicity.

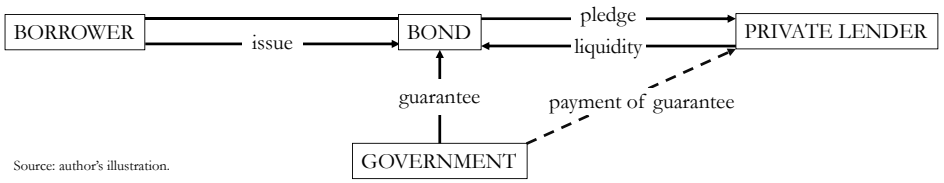
Table 8.2: Probability of government guarantee to be called (case of independence)

Event	Probability	Payout
counterparty and collateral default	$(1-p_L)\cdot(1-q) \equiv p^e_\lambda$	c^e or $\overline{c}^e$
counterparty defaults but collateral survives	$(1-p_L)\cdot q$	0
counterparty survives but collateral defaults	$p_L\cdot(1-q)$	0
counterparty and collateral survive	$p_L\cdot q$	0

Source: author's compilation.

the government that would only be required if the guarantee is called, i.e. it takes place with probability p^e_λ. In this case, the government pays any outstanding principal and interest to the private lender.

Figure 8.5: Course of action for bond pledged in *private* repo



Consider the payment of government l to the private lender to be given by $\overline{c}^e = (1+i_L)\Phi$, with i_L being the repo rate and Φ principal.[365] Hence, the expected cost for government l from guaranteeing this bond are

$$\mathbb{E}[\overline{c}^e] = p^e_\lambda \underbrace{(1+i_L)\Phi}_{\overline{c}^e}. \tag{8.1}$$

Guaranteed Bond Used as Collateral with the Eurosystem

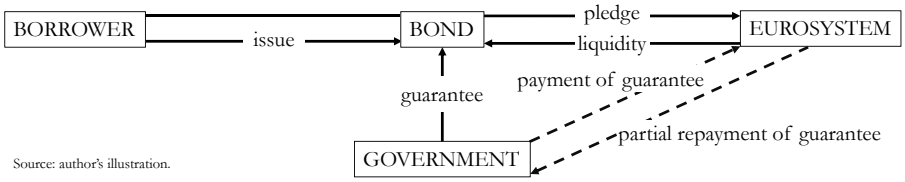
The course of action in case of a government guarantee to a bond that is eligible and pledged as collateral in a public repo with the Eurosystem is depicted in Figure 8.6. Actions are similar except for the potential payment from the Eurosystem to the government. Owing to the sharing of profits and losses in the Eurosystem, the government de facto becomes a beneficiary of the payment that it has to make when the guarantee is called. In this case, it pays principal and interest to the Eurosystem and receives back a fraction of this payment via its NCB ("partial repayment of guarantee").[366]

Let k_l be the fraction according to which country l participates in profits of the Eurosystem, with $\sum_l k_l = 1$. Hence, the government would have to pay principal and interest, i.e. $(1+i_L)\Phi$,

[365] Φ resembles the collateral value used in previous chapters as haircuts are neglected here.

[366] The NCB of country l receives a fraction of the Eurosystem's profit according to paid-up capital, see ECB 2012e and Chapter 7. For simplicity, profit retention by the ECB and NCBs is neglected and all payments are assumed to take place in the same period.

Figure 8.6: Course of action for bond pledged in *public* repo



if the guarantee was called but it would de facto receive back a fraction of its payment, i.e. $k_l i_L \Phi$.[367] The expected costs of the guarantee are given by

$$\mathbb{E}[c^e] = p_\lambda^e \underbrace{(1-k_l)(1+i_L)\Phi}_{c^e}. \tag{8.2}$$

Comparison of Expected Cost

The comparison of Equations (8.1) and (8.2) reveals that ceteris paribus, $\mathbb{E}[c^e] < \mathbb{E}[\bar{c}^e]$ as $0 < k_l < 1$. This shows that the expected cost from guaranteeing a bond pledged as collateral with the Eurosystem is lower than guaranteeing a bond used as collateral in a private repo. This strengthens the incentive to guarantee assets that comply with the Eurosystem collateral framework.[368] Based on data on eligible collateral in the Eurozone, the maximum hypothetical total savings in expected costs from granting new guarantees to assets that can be pledged as collateral with the Eurosystem rather than ineligible assets are estimated for the period from May 2007 to December 2013. Using information on the nominal value of new government guarantees to eligible marketable assets for Φ, the year-average refinancing rate for i_L and the shares of paid-up capital for k_l, maximum total hypothetical savings are estimated at EUR 430.1 bn for Germany, EUR 85.5 bn for France, EUR 33.6 bn for Spain, EUR 23.4 bn for Italy, EUR 6.5 bn for Greece, EUR 6.1 bn for Ireland and EUR 1.8 bn for Portugal.[369]

8.4.2 Benefits of a Government Guarantee

The government may benefit from granting explicit guarantees to eligible bonds via two channels, i.e. *(i)* an *implicit guarantee channel* and *(ii)* a *borrowing cost channel*. The two channels are briefly explained in the following and qualitatively introduced into the technical approach. Hence, qualitative assumptions are made concerning the effects of explicit guarantees without making assertions on quantitative effects.

[367] Note that the financial means that the government pays to itself is not restricted to the fraction of interest payments. Over the infinite horizon, the government receives back the fraction of its *entire* payment, i.e. $k_l(1+i_L)\Phi$, since the payment sustains the monetary base to be backed by interest-bearing assets. The present value of interest payments on these assets over the infinite horizon is equal to principal.

[368] Note that an akin narrative holds for government bonds used as collateral with the Eurosystem (see Section 6.5.1).

[369] Of course, the actual savings are substantially lower as eligible guaranteed assets have to be pledged and the probability of double default as well as profit retention by the ECB and NCBs have to be taken into account.

Implicit Guarantee Channel

Explicit government guarantee schemes are usually restricted to banks fulfilling certain institution criteria such as systemic importance or a minimum market share and they require minimum bond issue volumes.[370] Therefore, institution criteria as well as the minimum bond value imply the prerequisite that banks intending to benefit from an explicit guarantee should be systemically important. The implicit guarantee channel refers to the benefit that the government derives from the alleviating effect that an additional *explicit* guarantee has on the *implicit* guarantee, which systemically important banks already enjoy owing to their TBTF status (Section 6.3). This triggers dynamics within the government liability matrix (Table 6.2) as a contingent implicit liability is transformed to a contingent explicit liability. This effect is considered in the technical analysis by considering the cost of the implicit guarantee c^i as being negatively dependent on Φ, i.e. the larger the explicit guarantee, the lower the implicit guarantee. The expected cost of the implicit guarantee to the banking sector is subsequently given by

$$\mathbb{E}[c^i] = \sigma p_\lambda^i c^i(\Phi), \tag{8.3}$$

with $\partial c^i/\partial\Phi < 0, \partial^2 c^i/\partial\Phi^2 > 0$ and $\partial^3 c^i/\partial\Phi^3 = 0$ such that c^i decreases with explicit guarantees Φ and this marginal effect decreases the larger that Φ is. Furthermore, $\mathbb{E}[c^i]$ depends on $\sigma \in (0,1)$, which reflects the impatience/panic of depositors. The higher σ, the more impatient depositors are and the lower their belief in the implicit guarantee. Therefore, σ refers to a panic component in the spirit of Diamond and Dybvig 1983. According to ibid., any sufficient explicit guarantee would imply $\sigma = 0$ such that the government would be able to perfectly mitigate the expected cost of the implicit guarantee. However, owing to the drawbacks of government guarantees (e.g. solvency concerns and moral hazard, see Section 8.3), the government is deemed unable to do so and σ is strictly positive.

Borrowing Cost Channel

This channel was already backed up in Section 6.5.1 and elaborated in Section 7.5 in a slightly different context. It originates from the close tie between collateral criteria and government guarantees and the observable development that banks increased their holdings of (domestic) government debt after drawing liquidity from the Eurosystem. This behavior can be explained by several reasons, most importantly risk shifting and moral suasion (Section 6.5.1). Banks in particular engaged in this behavior during the "big bazooka" period in which extended liquidity provision by the Eurosystem was made possible by governments providing collateral to banks in their territory via explicit government guarantees. The negative relationship between domestic government bond holdings and government borrowing cost (see Acharya and Steffen 2015 and Asonuma et al. 2015) suggests that governments were able to reduce borrowing costs

[370] See Muller et al. 2012 for a comprehensive survey of government guarantee schemes initiated in Europe in response to the financial crisis. For instance, institution criteria comprise the requirement for the systemic importance of supported credit institutions (see e.g. the Irish government guarantee scheme). For the prerequisite of a minimum market share, see e.g. the Spanish government guarantee scheme, and the requirement of a minimum value, see e.g. the joint guarantee scheme of Belgium, France and Luxembourg.

by granting explicit guarantees.[371] The beneficial effect of explicit guarantees on government borrowing cost is incorporated into the analysis by allowing for a negative relationship between Φ and the interest rate on government bonds i such that[372,373]

$$i \equiv i(\Phi), \tag{8.4}$$

with $\partial i/\partial \Phi < 0$, $\partial^2 i/\partial \Phi^2 > 0$ and $\partial^3 i/\partial \Phi^3 < 0$. Hence, more explicit guarantees implicitly induce (at least some) additional demand for government bonds, which gives rise to the negative relationship between Φ on i. The marginal effect on i decreases the larger that Φ is.

8.4.3 The Optimal Level of Government Guarantees

The government's decision to grant explicit guarantees evolves around the trade-off of the costs and benefits of the guarantee, which differ between different types of assets, i.e. newly eligible, already-eligible and ineligible assets. For any type of assets, the government would enjoy lower expected costs of the implicit guarantee from the explicit guarantee. Moreover, the government would benefit from a lower interest rate on its debt if the explicit guarantee was given to newly eligible assets. However, the explicit guarantee constitutes an explicit fiscal risk, which would adversely affect its budget if the risk materialized. This potentially adverse effect is larger for ineligible rather than eligible assets, as the expected cost differ.

The application of the framework for analyzing fiscal sustainability (Section 6.4) facilitates characterizing the government's optimal choice regarding the level of explicit guarantees within the given environment. Abstracting for simplicity from economic growth and inflation,[374] the stylized sustainability indicator given by Equation (6.18) can be exemplified for *newly eligible assets* as[375]

$$pb = i(\Phi)d - \gamma + p^e_\lambda(1 - k_l)(1 + i_L)\Phi + \sigma p^i_\lambda c^i(\Phi). \tag{8.5}$$

The government's optimal choice with respect to the level of explicit guarantees to newly eligible assets is determined by

$$\Phi^* = \underset{\Phi \in [0, \overline{\Phi}]}{\arg\min}\, pb(\Phi). \tag{8.6}$$

[371] This implies that the assessment of governments' financial standing is unaffected by explicit guarantees, e.g. because the explicit guarantees replaced already-existing implicit guarantees.

[372] In the previous chapter, i was negatively dependent on the level of collateral criteria. In this chapter, the level of collateral criteria is taken as given but the government can decide on the amount of explicit guarantees Φ.

[373] Only a qualitative but no quantitative statement is made on the relation between Φ and i. The negative relationship holds for any (small) additional demand for government bonds from extra liquidity that was freed up by explicit guarantees. Granting the explicit guarantee has per se no effect on the interest rate as government's financial standing is unaffected, e.g. because an implicit guarantee is made explicit.

[374] This simplifies the analysis as the real interest rate is approximated by the nominal interest rate and potential crowding-out of private investment is neglected, see Section 7.5.

[375] The analysis can be enriched by considering γ to be dependent on Φ. If explicit government guarantees freed up collateral and increased borrowing from the Eurosystem, central bank income would increase, thus resulting in a higher γ. The qualitative results would remain unchanged.

Φ is assumed to be restricted for newly eligible assets to the interval $[0, \overline{\Phi}]$ with $\overline{\Phi}$ representing the upper limit on the amount of pledgeable government-guaranteed bonds, i.e. $\overline{\Phi}$ is specified by the collateral framework.[376] The optimal level of government guarantees is characterized by

$$\underbrace{-\left[\frac{\partial i}{\partial \Phi^*} d + \sigma \frac{\partial c^i}{\partial \Phi^*} p_\lambda^i\right]}_{\text{exp. marginal benefit}} = \underbrace{p_\lambda^e (1 - k_l)(1 + i_L).}_{\text{exp. marginal cost}} \tag{8.7}$$

The government chooses Φ^* by balancing the expected marginal benefit in terms of lower interest payments on its debt (first term on the left-hand side) and a lower implicit fiscal risk (second term on the left-hand side) against the expected marginal cost in terms of an explicit fiscal risk (right-hand side).

Table 8.3 provides an overview of the expected marginal costs and benefits of explicit guarantees to the three assets types. As the expected marginal costs and benefits differ between asset types, optimal levels of explicit guarantees differ. The government has the strongest incentive to guarantee newly eligible assets as it only enjoys the borrowing cost effect by guaranteeing such assets. It has the second strongest incentive to guarantee assets that are eligible irrespective of the guarantee as although the borrowing cost effect vanishes, the expected costs of the guarantee are still lower than for assets that are ineligible. Accordingly, the government has the weakest incentive to guarantee ineligible assets.

Table 8.3: Marginal costs and benefits of explicit government guarantees by asset type

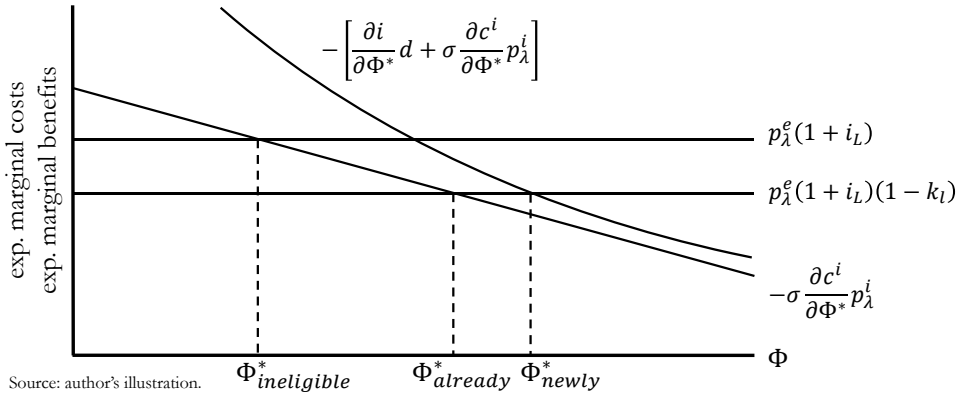
Asset Type	Exp. Marginal Benefits	Exp. Marginal Costs
newly/renewed eligible asset e.g. own-use uncovered bank bond	$-[\frac{\partial i}{\partial \Phi} d + \sigma \frac{\partial c^i}{\partial \Phi} p_\lambda^i]$	$p_\lambda^e (1 + i_L)(1 - k_l)$
already-eligible asset e.g. covered bank bond	$-\sigma \frac{\partial c^i}{\partial \Phi} p_\lambda^i$	$p_\lambda^e (1 + i_L)(1 - k_l)$
ineligible asset e.g. subordinated bond	$-\sigma \frac{\partial c^i}{\partial \Phi} p_\lambda^i$	$p_\lambda^e (1 + i_L)$

Source: author's compilation.

Optimal levels of explicit guarantees to the different asset types are illustrated in Figure 8.7, which reflects the expected marginal costs and benefits as summarized in Table 8.3. The expected marginal benefit of guaranteeing newly eligible assets is given by the downward-sloped curve comprising both the borrowing cost effect and the implicit guarantee effect. The downward-sloped line represents the expected marginal benefit of guaranteeing already-eligible and ineligible assets and reflects only the implicit guarantee effect. The upper horizontal line gives the (higher) expected marginal cost of guaranteeing ineligible assets while the lower horizontal line depicts the (lower) cost of giving an explicit guarantee to eligible assets. The figure confirms the finding that the optimal level of explicit guarantees is the largest for newly eligible assets, followed by already-eligible assets and finally ineligible assets.

[376] For instance, the Eurosystem limited the amount of pledgeable government-guaranteed bank bonds with close links in July 2012, see Section 3.2.2.

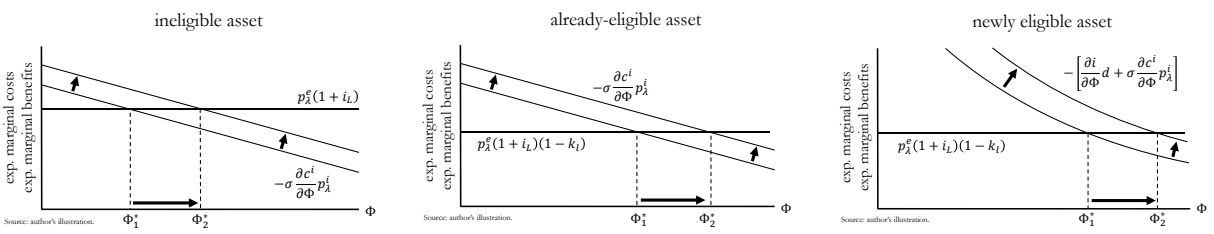
Figure 8.7: Optimal levels of explicit government guarantees by asset type



The findings contribute to explain the observable development of explicit government guarantees in the Eurozone, as summarized by the Stylized Facts 8.1 and 8.2. The financial and the sovereign debt crisis had distinct effects on government incentives to grant explicit guarantees. While turmoil in financial markets predominantly affected the impatience/panic of depositors, the surge in public indebtedness increased debt ratios and interest rates on government debt. Variations in three determinants of government incentives to grant explicit guarantees are elaborated in the following, i.e. *(i)* increased depositor impatience/panic, *(ii)* deterioration in the fiscal position and *(iii)* the relaxation of collateral criteria. It is shown that variation in these determinants can facilitate explaining the observable development of government guarantees in the Eurozone.

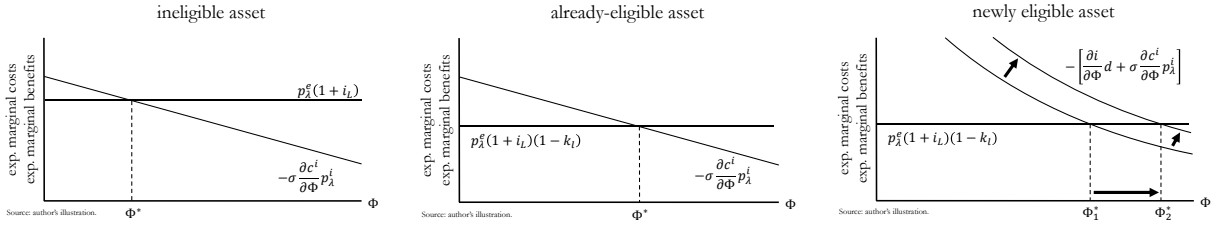
Increase in Depositor Impatience/Panic Several Eurozone countries' banking sectors faced a surge in depositor impatience during the financial crisis, which culminated in panic in several countries (see e.g. Sinn 2010a). As a result, governments deemed it necessary to grant explicit guarantees in large amounts to already and newly eligible marketable assets of struggling financial institutions (Figure 8.3 and Muller et al. 2012). The surge in depositor impatience corresponds to an increase of σ, which in turn makes existing implicit guarantees ceteris paribus more expensive as depositors contest the credibility of the implicit guarantees. The three panels of Figure 8.8 reveal how a shock to σ increases government incentives to grant explicit guarantees to all three types of assets. This contributes to explain the observation that explicit government guarantees grew in importance throughout the financial crisis (Stylized Fact 8.1) and were likewise given to newly as well as already-eligible marketable assets (Stylized Fact 8.2).

Figure 8.8: Increase in depositor impatience and optimal levels of expl. gov. guarantees



Deterioration in the Fiscal Position By contrast, explicit government guarantees were almost exclusively given to newly eligible marketable assets during the "big bazooka" period with extended liquidity provision by the Eurosystem (Stylized Fact 8.2). This period was preceded by the deterioration of fiscal positions in several Eurozone countries in terms of a surge in debt ratios and interest rates. The rise in the debt ratio and the interest rate augments the beneficial effect of explicit guarantees to newly eligible assets (through the borrowing cost channel). The three panels of Figure 8.9 depict the impact of the exogenous rise of d and i on the optimal level of explicit guarantees to the three types of assets. The figure reveals that the shock only affects the incentive to explicitly guarantee newly eligible assets. This could explain the stylized fact that the structure of new explicit government guarantees to eligible marketable assets changed, i.e. guarantees were predominantly given in crisis-stricken countries to newly eligible marketable assets during the "big bazooka" period (Stylized Fact 8.2).

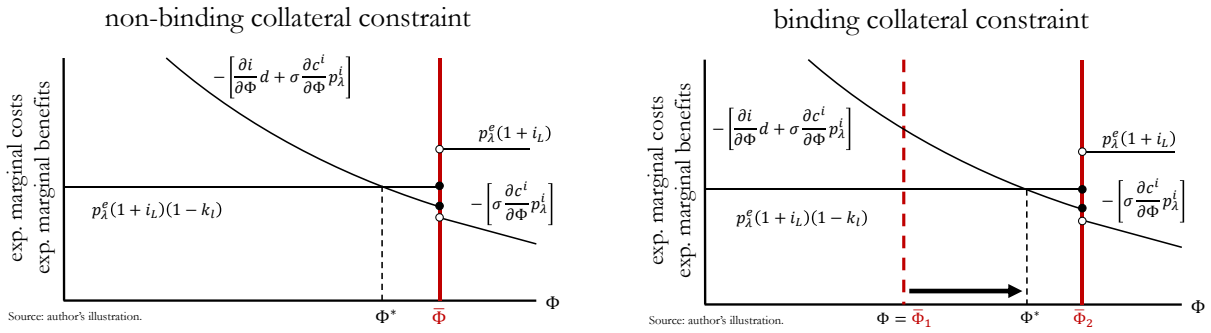
Figure 8.9: Deterioration in the fiscal position and optimal levels of expl. gov. guarantees



Relaxation of Collateral Criteria Over recent years, the Eurosystem has facilitated the growing importance of government guarantees by relaxing collateral criteria inter alia with respect to government-guaranteed assets, i.e. it increased the limit on the amount of pledgeable government-guaranteed bonds $\overline{\Phi}$. Whether such an increase in $\overline{\Phi}$ affects the optimal level of government guarantees depends on whether the collateral constraint implicitly imposed by the central bank is binding. It is non-binding for $\Phi^* \leq \overline{\Phi}$ but binding otherwise. The case of a non-binding collateral constraint is illustrated in the left panel of Figure 8.10. To the left of the red line, explicit guarantees are given to newly eligible bonds such that the expected marginal benefits are decreasing and convex and expected marginal costs are low. The collateral constraint induces a discontinuity in both the expected marginal benefits and costs. To the right of the red line, the expected marginal benefits are lower and linearly falling (as it solely reflects the implicit guarantee effect) and expected marginal costs are higher as guaranteed assets are ineligible. It is obvious that a relaxation of collateral criteria, which would shift $\overline{\Phi}$ to the right, would not affect Φ^*, which is already optimal given the initial $\overline{\Phi}$. By contrast, the right panel of Figure 8.10 depicts the case of a binding collateral constraint. The initial collateral constraint is depicted by the dashed line and the government chooses $\Phi = \overline{\Phi}_1 < \Phi^*$ prior to any relaxation of collateral criteria. The relaxation of collateral criteria increases $\overline{\Phi}_1$ to $\overline{\Phi}_2$ and the government responds optimally by extending guarantees to Φ^*. This contributes to explain the observation that government guarantees grew in importance during the financial crisis when the Eurosystem relaxed collateral criteria related to government-guaranteed assets (Stylized Fact 8.1). Moreover, it supports understanding why the majority of explicit government guarantees

were given to newly eligible assets and particularly uncovered bank bonds that were deemed eligible if own-use provided that they were government-guaranteed (Stylized Fact 8.2).

Figure 8.10: Relaxation of collateral criteria and optimal level of expl. gov. guarantees



This chapter has provided a novel rationale for government guarantees, extending the common rationale that justifies government guarantees based on their capability to avoid bank runs (Diamond and Dybvig 1983). The novel rationale was derived from a fiscal perspective in due consideration of the close tie between collateral criteria and government guarantees. Government incentives to provide explicit guarantees were characterized based on the costs and benefits of guarantees, which differ between *(i)* newly eligible, *(ii)* already-eligible and *(iii)* ineligible assets. Moreover, the importance of variations in *(i)* depositor impatience, *(ii)* the fiscal position and *(iii)* collateral criteria by explicit government guarantees and their structure were emphasized. Collateral criteria thus bear a fiscal implication as they affect government incentives to grant explicit guarantees, i.e. to assume contingent explicit liabilities.[377] Despite the beneficial effect of government guarantees from a fiscal perspective, governments' discretion to free up collateral should be limited for the following reasons. First, the anticipation of explicit guarantees can give rise to moral hazard and risk shifting such that financial institutions are incentivized to take excessive risk. Second, while explicit government guarantees to illiquid but solvent banks can be beneficial, governments may fail to identify those banks and provide guarantees to illiquid and insolvent banks. This would be unfavorable from a fiscal perspective as it would increase future costs to the government from bank bailouts. Third, governments' discretion to free up collateral results in governments striving for the provision of explicit guarantees to assets that would not have been eligible otherwise. An ever-looser collateral framework thus incentivizes governments to guarantee assets of ever-decreasing quality. Finally, the amplified incentive for governments to give explicit guarantees fosters the nexus between governments and the financial sector, particularly in times when the nexus unfolds its unfavorable effects (see Section 8.3).

[377] van Bekkum et al. 2015 address another fiscal implication of collateral criteria in terms of government guarantees. The authors examine the effects of Eurosystem collateral policy in the Netherlands regarding the quality of assets backing RMBS. They find that deterioration of the quality of underlying assets is only present for loans with government guarantees and refer this finding to undesired risk shifting from banks to the government.

9

Conclusion

9.1 Summary: the Eurosystem Collateral Framework and its Fiscal Implications

The dissertation has elaborated on the Eurosystem collateral framework and its fiscal implications.[378] A narrative database of amendments to the collateral framework was compiled, revealing that the Eurosystem predominantly relaxed collateral criteria, particularly in response to the financial and the sovereign debt crisis. It was elaborated that the Eurosystem thereby broadened the pool of eligible marketable assets ("collateral pool") both horizontally and vertically at the aggregated and national level. It was shown that amendments to collateral criteria affected the Eurosystem collateral pool with respect to geographical composition, composition by asset type, the credit quality of eligible marketable assets, the denomination of eligible marketable assets, markets in which eligible assets were traded, the fraction of government-guaranteed marketable assets and the residual maturity of eligible marketable assets.

The Eurosystem adjusted its risk control in response to the development of the collateral pool. However, valuation haircuts as the major risk mitigation tool were applied in a simplified way and only adjusted infrequently. The application of simplified haircuts aligns collateral values that are assigned to assets with different properties. Such an alignment gives rise to imperfect risk control and the adverse selection of collateral, i.e. the Eurosystem likely attracts collateral of relatively low quality while high-quality collateral is pledged in the market. The attraction of low-quality collateral would be intensified and beyond the control of the central bank if credit ratings were positively distorted. The adverse selection of collateral facilitates the understanding of empirical evidence that default probabilities of eligible and pledged collateral have developed asymmetrically in the Eurozone over recent years. Hence, the Eurosystem's risk exposure has substantially increased owing to relaxations of collateral criteria but imperfect risk control. Relaxations implied a deterioration in collateral quality, which was reinforced by the adverse

[378] See Section 1.2 for a detailed overview of the main findings.

selection of collateral, while the associated increase in collateral risk was insufficiently hedged by simplified haircuts.

Two fiscal implications of amendments to collateral criteria were addressed. First, the implementation of uniform collateral criteria in a monetary union of heterogeneous countries gives rise to risk-sharing among countries owing to the mutualization of potential costs of a central bank bailout. If the common central bank relaxed uniform collateral criteria, risk-sharing would be extended and fiscal positions would be affected from a transfer of fiscal sustainability across countries. Second, amendments to collateral criteria directed at the eligibility of government-guaranteed assets incentivize governments to initiate new or extend existing explicit guarantees, i.e. to assume contingent liabilities that are not contractually agreed.

The following final section presents a stylized proposal for an improved collateral framework from a fiscal perspective that specifically addresses the previously-identified flaws of Eurosystem collateral criteria.

9.2 An Improved Collateral Framework from a Fiscal Perspective

This section proposes an improved framework from a fiscal perspective that takes up one of the subtleties of the current framework and bases on past practice. Moreover, nine principles are carved out for the proposed framework that are formulated as to circumvent shortcomings identified for the current framework. Taking into account the proposed principles would improve risk control and curtail the adverse selection of collateral such that additional collateral risk from relaxed collateral criteria would be better hedged.[379]

9.2.1 Structure of the Proposed Collateral Framework

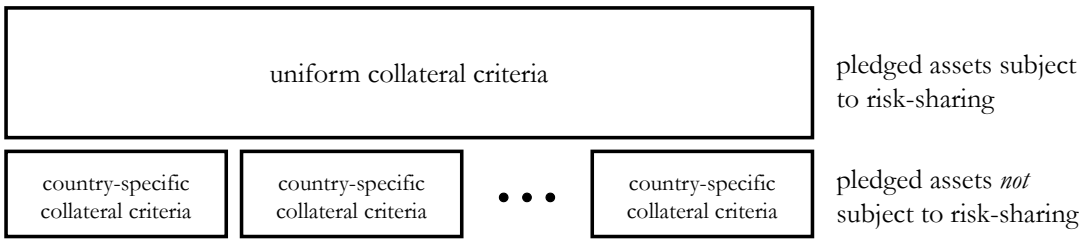
The proposed framework features a two-tier structure that resembles the design of the initial collateral framework. Its major advantage is that it would sidestep excessive risk-sharing among countries, which would give rise to the transfer of fiscal sustainability. The first tier comprises collateral criteria that are uniform across the Eurozone, while the second tier leaves room for country-specific collateral provisions.[380] The general structure of the proposed two-tier collateral framework is illustrated in Figure 9.1 and further explained in the following.

The uniform Eurozone-wide collateral criteria of the first tier are laid down by the ECB. Improved risk control owing to the principles specified in Section 9.2.2 would imply Treasuries tolerating a lower level of collateral criteria as the additional collateral risk would be better

[379] In the light of the model of Section 7.5, it would imply that the marginal probability of central bank bailout $\partial p^i_\lambda / \partial \hat{q}$ would progress flatter (owing to the restraint of the adverse selection) and on a lower level (owing to improved risk control).

[380] Note that the proposed framework predominately addresses risk-sharing in the monetary income of the Eurosystem. While Chapter 7 elaborated that collateral criteria are also vital for the accumulation of intra-Eurosystem balances and the provision of ELA, these two issues should be separately addressed. While the accumulation of intra-Eurosystem balances should be tackled by implementing an appropriate settlement mechanism (see e.g. SINN 2012, 2014b), the proposed framework would render ELA redundant as the provision of refinancing loans based on country-specific collateral criteria on the condition that governments are solvent would resemble ELA while being more transparent.

Figure 9.1: Structure of the proposed two-tier collateral framework



Source: author's illustration.

hedged. The proposed framework still involves risk-sharing among countries, whereby the degree depends on the level of uniform collateral criteria. First, a cautious ECB would implement a level of uniform collateral criteria that corresponds to the lowest common denominator of the countries, i.e. the strictest level preferred by one of the countries. This level would be the most consistent with the primary purpose of collateral as a risk hedge. Moreover, it would imply a small extent of risk-sharing and a small transfer of fiscal sustainability. A less cautious ECB acting as an utilitarian social planner with the aim of implementing the optimal level of uniform collateral criteria for the entire Eurozone from the fiscal perspective would specify an intermediate level (Section 7.5). This level would be stricter than the lowest preferred level but still looser than the strictest preferred level. It would give rise to a larger extent of risk-sharing relative to the previous level and a larger transfer of fiscal sustainability. Finally, the level of collateral criteria could be subject to democratic decision-making in the ECB Council, which would likewise give rise to an intermediate level of collateral criteria. Specifically, agreement on the level of collateral criteria in the Council should be based on voting power reflecting contribution to potential losses and central bank bailout, respectively, rather than on a one-country one-vote basis.

Heterogeneous countries fiscally desire distinct levels of collateral criteria. Distinct preferences can be amplified in case of asymmetric shocks to e.g. fiscal positions. If country-specific preferences were answered by uniform collateral criteria in the first tier, risk-sharing among countries would be intensified. Therefore, the second tier of the proposed collateral framework enables NCBs of solvent countries to formulate country-specific collateral criteria.[381] However, it exempts assets pledged under these criteria from risk-sharing in the Eurosystem. Accordingly, risk-sharing is restricted to assets pledged under the uniform tier-one collateral criteria but is suspended for assets pledged according to country-specific tier-two criteria. From a fiscal perspective, the country-specific level of collateral criteria would optimally solve the trade-off between the expected marginal costs and benefits of amending collateral criteria for each country.

The proposed two-tier framework mimics the design of the initial Eurosystem collateral framework (Section 3.1.1). Moreover, it takes up a subtlety of the current framework by resembling

[381] The establishment of country-specific collateral criteria is restricted to NCBs of solvent countries; otherwise, country-specific collateral criteria would not be justifiable from a fiscal perspective as an insolvent government could not back its NCB. However, government backup is vital as the finances of the affected NCB would be weakened in case of counterparty and collateral default and without loss-sharing, given that it would have to compensate the other NCBs for the permanent loss in interest income. See the discussion on income from money creation in Section 7.3.1 and the discussion on ELA in Section 7.3.2.

the risk-sharing features of ACCs (Section 3.2.1). The initial framework featured two tiers of collateral criteria, i.e. a tier comprising uniform collateral criteria and a tier including country-specific provisions. However, potential losses were shared irrespective of the collateral criteria according to which assets were pledged.[382] By contrast, potential write-off losses on assets pledged under the ACCs framework were not mutualized but would have to be borne by the affected NCB.

The proposed framework would offer the advantage of circumventing excessive risk-sharing and the transfer of fiscal sustainability. Moreover, it would be based on the fundamental economic principle of liability (provided that governments are and remain solvent). However, it would oppose the Eurosystem's endeavor to facilitate the integration of financial markets via uniform collateral criteria. Instead, it would give rise to a collateral framework with criteria differing across Eurozone countries. The proposed framework would reduce the complexity of the current framework, which is characterized by a myriad of temporary and country-specific provisions, resulting in excessive risk-sharing and transfer of fiscal sustainability. The proposed framework would lay down clear-cut ex ante rules with respect to uniform and country-specific collateral criteria. Moreover, the restriction to risk-sharing would likely render country-specific collateral redundant. The proposed framework can be regarded as a transient framework until a European political and fiscal union is established. A European fiscal authority backing the common central bank would justify a uniform level of collateral criteria involving a larger degree of risk-sharing.

9.2.2 Principles of the Proposed Collateral Framework

Finally, the following formulates nine principles evolving from the previous analysis of the Eurosystem collateral framework that collateral criteria specified for both tiers of the proposed framework should respect to improve risk control.[383]

1. Restriction of Collateral with Close Links Collateral criteria should restrict the eligibility of assets with close links (or even own-use) as the risk-hedging effect is diminished when these assets are pledged as collateral (Section 7.3.1).

2. Restriction of the Role of Government Guarantees It was shown in Chapter 8 that amendments to the collateral criteria of government-guaranteed assets affect government incentives to give explicit guarantees. Although Section 8.4 revealed that government guarantees can be beneficial to the government from a fiscal perspective, the section also outlined reasons why government discretion to free up eligible assets via explicit guarantees should be restricted.

3. Restriction of Theoretical Valuation of Assets Eligible assets are valued theoretically when they do not feature a market value (e.g. in case of non-marketable or own-use assets) or when

[382] Another difference between the initial two-tier framework and the proposed one is that in the initial framework assets included in the country-specific tier were not deemed eligible for purchases.
[383] See also NYBORG 2015 for shortcomings of the current Eurosystem collateral framework.

their market price has not moved for at least five days (Section 3.1.4.2).[384] However, theoretical values give rise to potential valuation errors, which would increase the risk exposure of the Eurosystem (Section 5.3.2.1). Therefore, the leeway of theoretical valuation should be restricted.

4. Restriction of Non-Marketable Assets Theoretical valuation owing to a lacking market value is particularly important for non-marketable assets that also feature low liquidity. Therefore, the eligibility of non-marketable assets should be restricted in due consideration of their increased pledge with the Eurosystem over recent years (Section 5.1).

5. Restriction of Assets Traded on Non-Regulated Markets Assets traded on non-regulated markets often lack an up-to-date market value and have to be theoretically valued (NYBORG 2015). Section 3.2.3 raised concerns about the assessment of non-regulated markets with respect to the stipulated principles of safety, transparency and accessibility. Specifically, the application of the principle of transparency was exemplarily questioned for the STEP market (Section 3.2.3). Owing to the lack of up-to-date market values and their opacity, which contradicts the principle of transparency, the eligibility of assets traded on non-regulated markets should be restricted.

6. More Graduated Haircuts Haircuts are the most important risk control measure to the Eurosystem and they should be as graduated as possible.[385] The guiding principle of haircut specification should be that they reflect all available information and are based on market input (ibid.). Therefore, haircuts should mirror asset properties such as coupon, liquidity, credit quality and residual maturity as accurately as possible (Section 4.3.2). More graduated haircuts (as indicated in Figure 4.3) would give rise to differentiated rather than pooled refinancing conditions based on asset properties. This would minimize the peril of adverse selection of collateral as the subsidization of low-quality collateral would be circumvented.

7. More Frequent Revision of Haircuts Section 4.2.2 indicated that haircut revision was infrequent and often delayed or unrelated to events exogenous and endogenous to the Eurosystem. However, given that haircuts are the most important risk control measure of the Eurosystem, they should be revised frequently and in instantaneous response to relevant events. Furthermore, more frequent, timely and accurate revision of haircuts is indispensable to minimize the peril of adverse selection of collateral.

8. Simultaneous Application of Risk Control Measures Furthermore, the bias in haircuts from the sequential application of risk control measures (Section 4.3.2.3) should be resolved. Risk control via valuation haircuts and supplementary haircuts in terms of valuation markdowns should thus occur simultaneously.

[384] NYBORG 2015 reports that about 77% by count or 17% by value of eligible assets feature theoretical values.
[385] If the Eurosystem applied oversimplified haircuts to improve the liquidity of certain assets or facilitate liquidity provision, it would become redundant within the proposed framework as NCBs could lay down country-specific collateral criteria to mimic the envisaged effect and bear the emerging risk.

9. Rejection of First-Best Rule The Eurosystem applies the first-best rule to eligible assets other than ABSs for determining of the pivotal credit rating (Section 3.2.1). Section 4.3.2.1 reasoned that the application of the first-best rule is associated with three flaws, i.e. *(i)* information available on collateral credit quality is potentially neglected; *(ii)* rating agencies are incentivized to provide the pivotal credit rating, which could give rose to a "race to the top" of ratings irrespective of actual credit quality; and *(iii)* "ratings shopping" of counterparties is facilitated. A rejection of the first-best rule and stipulation and consultation of more than one credit rating would avoid these flaws.

Appendix to Chapter 5

Derivation of Equation (5.1)

Let the binary variable $I(\theta_j)$ be either 1 if bond j is traded on the market or 0 otherwise. Rent of borrowers R_B is given by the area underneath the price curve in Figure 5.9. As all bonds are traded at the distinct price $\rho(\theta_j) = \theta_j$, R_B reads as

$$R_B = \int_{\underline{\theta}}^{\bar{\theta}} I(\theta)\rho(\theta)\ d\theta = \int_{\underline{\theta}}^{\bar{\theta}} I(\theta)\theta\ d\theta = \int_{\underline{\theta}}^{\bar{\theta}} \theta\ d\theta = \left[\frac{1}{2}\theta^2\right]_{\underline{\theta}}^{\bar{\theta}} = \frac{\bar{\theta}^2 - \underline{\theta}^2}{2}.$$

Derivation of Equation (5.3)

Analogous to the derivation of Equation (5.1) and with the uniform price $\rho = \frac{\bar{\theta}+\underline{\theta}}{2}$, R_B and R, respectively, are given by

$$R_B = R = \int_{\underline{\theta}}^{\bar{\theta}} I(\theta)\rho\ d\theta = \int_{\underline{\theta}}^{\bar{\theta}} \frac{\bar{\theta}+\underline{\theta}}{2}\ d\theta = \left[\frac{(\bar{\theta}+\underline{\theta})\theta}{2}\right]_{\underline{\theta}}^{\bar{\theta}} = \frac{\bar{\theta}^2 - \underline{\theta}^2}{2}.$$

Derivation of Equation (5.4)

With a positively distorted signal and all bonds being traded with $\rho(\theta_j) = \max\Big(\theta_j + \epsilon, \bar{\theta}\Big)$, lenders suffer a loss in the amount of

$$\begin{aligned} R_L &= \int_{\underline{\theta}}^{\bar{\theta}} I(\theta)\Big(\theta - \rho(\theta)\Big)\ d\theta = \int_{\underline{\theta}}^{\bar{\theta}-\epsilon} I(\theta)\Big(\theta - (\theta+\epsilon)\Big)d\theta + \int_{\bar{\theta}-\epsilon}^{\bar{\theta}} I(\theta)(\theta - \bar{\theta})d\theta \\ &= [-\epsilon\theta]_{\underline{\theta}}^{\bar{\theta}-\epsilon} + \left[\frac{1}{2}\theta^2 - \bar{\theta}\theta\right]_{\bar{\theta}-\epsilon}^{\bar{\theta}} = -(\bar{\theta} - \underline{\theta} - \frac{1}{2}\epsilon)\epsilon < 0. \end{aligned}$$

Derivation of Equation (5.5)

Analogous to Equation (5.4), borrowers receive rent in case of a positively distorted signal given by

$$\begin{aligned} R_B &= \int_{\underline{\theta}}^{\bar{\theta}} I(\theta)\rho(\theta)\ d\theta = \int_{\underline{\theta}}^{\bar{\theta}-\epsilon} I(\theta)(\theta+\epsilon)d\theta + \int_{\bar{\theta}-\epsilon}^{\bar{\theta}} I(\theta)\bar{\theta}d\theta \\ &= \left[\frac{1}{2}\theta^2 + \theta\epsilon\right]_{\underline{\theta}}^{\bar{\theta}-\epsilon} + \left[\bar{\theta}\theta\right]_{\bar{\theta}-\epsilon}^{\bar{\theta}} = \frac{\bar{\theta}^2 - \underline{\theta}^2}{2} - \Big(\underbrace{-(\bar{\theta} - \underline{\theta} - \frac{1}{2}\epsilon)\epsilon}_{R_L}\Big). \end{aligned}$$

Derivation of Equation (5.6)

Considering $\alpha(\theta) = \theta - \underline{\theta}$ and that a fraction of bonds is traded in the market while the remainder is used with the outside option, rent of borrowers corresponding to aggregate surplus in the market is given by

$$\begin{aligned} R_B = R &= \int_{\underline{\theta}}^{\bar{\theta}} I(\theta)\rho \; d\theta + \int_{\underline{\theta}}^{\bar{\theta}} \Big(1 - I(\theta)\Big)\alpha(\theta) \; d\theta = \int_{\underline{\theta}}^{\theta_\alpha} \frac{\underline{\theta} + \theta_\alpha}{2} \; d\theta + \int_{\theta_\alpha}^{\bar{\theta}} (\theta - \underline{\theta}) \; d\theta \\ &= \left[\frac{(\underline{\theta} + \theta_\alpha)\theta}{2}\right]_{\underline{\theta}}^{\theta_\alpha} + \left[\frac{1}{2}\theta^2 - \theta\underline{\theta}\right]_{\theta_\alpha}^{\bar{\theta}} = \frac{\theta^2 - \underline{\theta}^2}{2} - \underline{\theta}(\bar{\theta} - \theta_\alpha). \end{aligned}$$

Derivation of Equation (5.19)

Rent of borrowers with pooled public repo conditions and correct ratings is given by

$$\begin{aligned} R_B &= \int_{\underline{\theta}}^{\bar{\theta}} I(\theta)\rho(\theta) \; d\theta + \int_{\underline{\theta}}^{\bar{\theta}} \Big(1 - I(\theta)\Big)\alpha(\theta) \; d\theta \\ &= \int_{\underline{\theta}}^{\hat{\theta}_3} s(\theta) \; d\theta + \int_{\hat{\theta}_3}^{\theta_{\alpha_3}} \alpha(\theta) \; d\theta + \int_{\theta_{\alpha_3}}^{\hat{\theta}_1} s(\theta) \; d\theta + \int_{\hat{\theta}_1}^{\theta_{\alpha_1}} \alpha(\theta) \; d\theta + \int_{\theta_{\alpha_1}}^{\bar{\theta}} s(\theta) \; d\theta \\ &= \int_{\underline{\theta}}^{\hat{\theta}_3} \theta \; d\theta + \int_{\hat{\theta}_3}^{\theta_{\alpha_3}} \frac{\hat{\theta}_1 + \hat{\theta}_3}{b_3} \; d\theta + \int_{\theta_{\alpha_3}}^{\hat{\theta}_1} \theta \; d\theta + \int_{\hat{\theta}_1}^{\theta_{\alpha_1}} \frac{\bar{\theta} + \hat{\theta}_1}{b_1} \; d\theta + \int_{\theta_{\alpha_1}}^{\bar{\theta}} \theta \; d\theta \\ &= \left[\frac{1}{2}\theta^2\right]_{\underline{\theta}}^{\hat{\theta}_3} + \left[\frac{(\hat{\theta}_1 + \hat{\theta}_3)\theta}{b_3}\right]_{\hat{\theta}_3}^{\theta_{\alpha_3}} + \left[\frac{1}{2}\theta^2\right]_{\theta_{\alpha_3}}^{\hat{\theta}_1} + \left[\frac{(\bar{\theta} + \hat{\theta}_1)\theta}{b_1}\right]_{\hat{\theta}_1}^{\theta_{\alpha_1}} + \left[\frac{1}{2}\theta^2\right]_{\theta_{\alpha_1}}^{\bar{\theta}} \\ &= \frac{\bar{\theta}^2 - \underline{\theta}^2}{2} + \underbrace{\frac{\hat{\theta}_1^2 + \hat{\theta}_3^2}{2} + \frac{1}{2}\left(\frac{\hat{\theta}_1 + \hat{\theta}_3}{b_3}\right)^2 + \frac{1}{2}\left(\frac{\bar{\theta} + \hat{\theta}_1}{b_1}\right)^2 - \frac{\hat{\theta}_3(\hat{\theta}_1 + \hat{\theta}_3)}{b_3} - \frac{\hat{\theta}_1(\bar{\theta} + \hat{\theta}_1)}{b_1}}_{\text{additional rent from pooled public repo conditions}}. \end{aligned}$$

Derivation of Equation (5.21)

Lenders sustain a loss with perfectly-pooled repo conditions and positively distorted ratings in the amount of

$$\begin{aligned} R_L &= \int_{\underline{\theta}}^{\bar{\theta}} I(\theta)\Big(\theta - \rho(\theta)\Big) \; d\theta = \int_{\underline{\theta}}^{\hat{\theta}_3 - \epsilon} \Big(\theta - s(\theta)\Big) \; d\theta + \int_{\theta_{\alpha_3} - \epsilon}^{\hat{\theta}_1 - \epsilon} \Big(\theta - s(\theta)\Big) \; d\theta + \int_{\theta_{\alpha_1} - \epsilon}^{\bar{\theta}} \Big(\theta - s(\theta)\Big) \; d\theta \\ &= \int_{\underline{\theta}}^{\hat{\theta}_3 - \epsilon} \Big(\theta - (\theta + \epsilon)\Big) \; d\theta + \int_{\theta_{\alpha_3} - \epsilon}^{\hat{\theta}_1 - \epsilon} \Big(\theta - (\theta + \epsilon)\Big) \; d\theta + \int_{\theta_{\alpha_1} - \epsilon}^{\bar{\theta} - \epsilon} \Big(\theta - (\theta + \epsilon)\Big) \; d\theta + \int_{\bar{\theta} - \epsilon}^{\bar{\theta}} (\theta - \bar{\theta}) \; d\theta \\ &= \Big[-\theta\epsilon\Big]_{\underline{\theta}}^{\hat{\theta}_3 - \epsilon} + \Big[-\theta\epsilon\Big]_{\theta_{\alpha_3} - \epsilon}^{\hat{\theta}_1 - \epsilon} + \Big[-\theta\epsilon\Big]_{\hat{\theta}_1 - \epsilon}^{\theta_{\alpha_1} - \epsilon} + \Big[-\theta\epsilon\Big]_{\theta_{\alpha_1} - \epsilon}^{\bar{\theta} - \epsilon} + \left[\frac{1}{2}\theta^2 - \bar{\theta}\theta\right]_{\bar{\theta} - \epsilon}^{\bar{\theta}} \\ &= -\left(\bar{\theta} - \underline{\theta} - \frac{1}{2}\epsilon + \hat{\theta}_1 + \hat{\theta}_3 - \frac{\hat{\theta}_1 + \hat{\theta}_3}{b_3} - \frac{\bar{\theta} + \hat{\theta}_1}{b_1}\right)\epsilon < 0. \end{aligned}$$

Derivation of Equation (5.22)

By contrast, borrowers benefit from positively distorted ratings and realize rent given by

$$
\begin{aligned}
R_B =& \int_{\underline{\theta}}^{\bar{\theta}} I(\theta)\rho(\theta)\ d\theta + \int_{\underline{\theta}}^{\bar{\theta}} \Big(1 - I(\theta)\Big)\alpha(\theta)\ d\theta \\
=& \int_{\underline{\theta}}^{\hat{\theta}_3-\epsilon} s(\theta)\ d\theta + \int_{\hat{\theta}_3-\epsilon}^{\theta_{\alpha_3}-\epsilon} \alpha(\theta)\ d\theta + \int_{\theta_{\alpha_3}-\epsilon}^{\hat{\theta}_1-\epsilon} s(\theta)\ d\theta + \int_{\hat{\theta}_1-\epsilon}^{\theta_{\alpha_1}-\epsilon} \alpha(\theta)\ d\theta + \int_{\theta_{\sigma_1}-\epsilon}^{\bar{\theta}} s(\theta)\ d\theta \\
=& \int_{\underline{\theta}}^{\hat{\theta}_3-\epsilon} (\theta+\epsilon)\ d\theta + \int_{\hat{\theta}_3-\epsilon}^{\theta_{\alpha_3}-\epsilon} \frac{\hat{\theta}_1+\hat{\theta}_3}{b_3}\ d\theta + \int_{\theta_{\alpha_3}-\epsilon}^{\hat{\theta}_1-\epsilon} (\theta+\epsilon)\ d\theta + \int_{\hat{\theta}_1-\epsilon}^{\theta_{\alpha_1}-\epsilon} \frac{\bar{\theta}+\hat{\theta}_1}{b_1}\ d\theta \\
&+ \int_{\theta_{\alpha_1}-\epsilon}^{\bar{\theta}-\epsilon} (\theta+\epsilon)\ d\theta + \int_{\bar{\theta}-\epsilon}^{\bar{\theta}} \bar{\theta}\ d\theta \\
=& \Big[\frac{1}{2}\theta^2 + \theta\epsilon\Big]_{\underline{\theta}}^{\hat{\theta}_3-\epsilon} + \Big[\frac{(\hat{\theta}_1+\hat{\theta}_3)\theta}{b_3}\Big]_{\hat{\theta}_3-\epsilon}^{\theta_{\alpha_3}-\epsilon} + \Big[\frac{1}{2}\theta^2 + \theta\epsilon\Big]_{\theta_{\alpha_3}-\epsilon}^{\hat{\theta}_1-\epsilon} + \Big[\frac{(\bar{\theta}+\hat{\theta}_1)\theta}{b_1}\Big]_{\hat{\theta}_1-\epsilon}^{\theta_{\alpha_1}-\epsilon} \\
&+ \Big[\frac{1}{2}\theta^2 + \theta\epsilon\Big]_{\theta_{\alpha_1}-\epsilon}^{\bar{\theta}-\epsilon} + \Big[\bar{\theta}\theta\Big]_{\bar{\theta}-\epsilon}^{\bar{\theta}} \\
=& \frac{\bar{\theta}^2 - \underline{\theta}^2}{2} + \underbrace{\frac{\hat{\theta}_1^2+\hat{\theta}_3^2}{2} + \frac{1}{2}\left(\frac{\hat{\theta}_1+\hat{\theta}_3}{b_3}\right)^2 + \frac{1}{2}\left(\frac{\bar{\theta}+\hat{\theta}_1}{b_1}\right)^2 - \frac{\hat{\theta}_3(\hat{\theta}_1+\hat{\theta}_3)}{b_3} - \frac{\hat{\theta}_1(\bar{\theta}+\hat{\theta}_1)}{b_1}}_{\text{add. rent from pooled public repo conditions}} \\
&+ \underbrace{\left(\bar{\theta} - \underline{\theta} - \frac{1}{2}\epsilon\right)\epsilon}_{\text{add. rent from rating distortion}}.
\end{aligned}
$$

Derivation of Equation (5.24)

Risk to the central bank from offering perfectly-pooled public repo conditions when ratings are positively distorted corresponds to

$$
\begin{aligned}
R_{CB} =& \int_{\underline{\theta}}^{\bar{\theta}} (1 - I(\theta)\Big(\theta - \alpha(\theta)\Big) = \int_{\hat{\theta}_3}^{\theta_{\alpha_3}} \Big(\theta - \alpha(\theta)\Big)\ d\theta + \int_{\hat{\theta}_1}^{\theta_{\alpha_1}} \Big(\theta - \alpha(\theta)\Big)\ d\theta \\
=& \Big[\frac{1}{2}\theta^2 - \frac{(\hat{\theta}_1+\hat{\theta}_3)\theta}{b_3}\Big]_{\hat{\theta}_3-\epsilon}^{\theta_{\alpha_3}-\epsilon} + \Big[\frac{1}{2}\theta^2 - \frac{(\bar{\theta}+\hat{\theta}_1)\theta}{b_1}\Big]_{\theta_{\alpha_1}-\epsilon}^{\hat{\theta}_1-\epsilon} \\
=& -\left(\frac{\hat{\theta}_1^2+\hat{\theta}_3^2}{2} + \frac{1}{2}\left(\frac{\hat{\theta}_1+\hat{\theta}_3}{b_3}\right)^2 + \frac{1}{2}\left(\frac{\bar{\theta}+\hat{\theta}_1}{b_1}\right)^2 - \frac{\hat{\theta}_3(\hat{\theta}_1+\hat{\theta}_3)}{b_3} - \frac{\hat{\theta}_1(\bar{\theta}+\hat{\theta}_1)}{b_1}\right) \\
&- \epsilon\left(\frac{\hat{\theta}_1+\hat{\theta}_3}{b_3} + \frac{\bar{\theta}+\hat{\theta}_1}{b_1} - \hat{\theta}_3 - \hat{\theta}_1\right).
\end{aligned}
$$

Appendix to Chapter 7

Derivation of Equation (7.6)

The present value of income flows from a certain central bank loan with nominal value L and duration T is given by

$$\begin{aligned} V_L &= \frac{i_L L}{(1+\beta)} + \frac{i_L L}{(1+\beta)^2} + \ldots + \frac{i_L L}{(1+\beta)^T} + \frac{L}{(1+\beta)^T} \\ &= \sum_{t=1}^{T} \frac{i_L L}{(1+\beta)^t} + \frac{L}{(1+\beta)^T} \\ &= i_L L \left(\frac{1-(1+\beta)^{-T}}{\beta} \right) + L(1+\beta)^{-T}. \end{aligned}$$

Derivation of Equation (7.7)

The present value of income flows from a chain of one-period central bank loans under certainty is obtained by solving Equation (7.6) recursively such that

$$\begin{aligned} V_L &= i_L L_0 \left(\frac{1-(1+\beta)^{-1}}{\beta} \right) + L_0(1+\beta)^{-1} \\ &= i_L L_0 \left(\frac{1-(1+\beta)^{-1}}{\beta} \right) + \left(i_L L_0 \left(\frac{1-(1+\beta)^{-1}}{\beta} \right) + L_1(1+\beta)^{-1} \right) (1+\beta)^{-1} \\ &= i_L L_0 \left(\frac{1-(1+\beta)^{-1}}{\beta} \right) \left(1 + (1+\beta)^{-1} \right) + L_1(1+\beta)^{-2} \\ &= \ldots \\ &= i_L L_0 \left(\frac{1-(1+\beta)^{-1}}{\beta} \right) \sum_{j=0}^{n} (1+\beta)^{-j} + L_j(1+\beta)^{-(j+1)}, \end{aligned}$$

where L_0 is the nominal value of the initial loan and L_j the constant nominal value of all replacement loans.

Derivation of Equation (7.13)

Dynamic seignorage under certainty allows for growth in the monetary base. Assuming that the monetary base grows in line with the economy at the rate g, dynamic seignorage comprises static

seignorage and the present value of interest payments from loans issued and assets purchased to back future base money issuance, i.e.

$$\begin{aligned}
\delta_{as}^{dyn} &= \delta_{as}^{stat} + \sum_{t=1}^{\infty} \frac{g\left(\frac{i_L}{\beta} L_{t-1} + \frac{i_A}{\beta} A_{t-1}\right)}{(1+\beta)^t} \\
&= \frac{i_L}{\beta} L_0 + \frac{i_A}{\beta} A_0 + \sum_{t=1}^{\infty} \frac{g(1+g)^{t-1}\left(\frac{i_L}{\beta} L_0 + \frac{i_A}{\beta} A_0\right)}{(1+\beta)^t} \\
&= \frac{i_L}{\beta} L_0 + \frac{i_A}{\beta} A_0 + \left(\frac{i_L}{\beta} L_0 + \frac{i_A}{\beta} A_0\right) \sum_{t=1}^{\infty} \frac{g(1+g)^{t-1}}{(1+\beta)^t} \\
&= \frac{i_L}{\beta} L_0 + \frac{i_A}{\beta} A_0 + \left(\frac{i_L}{\beta} L_0 + \frac{i_A}{\beta} A_0\right) \frac{g}{\beta - g} \\
&= (i_L L_0 + i_A A_0) \frac{1}{\beta - g}.
\end{aligned}$$

Derivation of Equation (7.16)

The present value of income flows from a chain of one-period central bank loans under uncertainty is derived analogously to Equation (7.7) and given by

$$\begin{aligned}
V_L &= i_L L_0 \left(\frac{p_L - (1+\beta)^{-1} p_L^2}{1+\beta-p_L}\right) + p_L L_0 (1+\beta)^{-1} \\
&= i_L L_0 \left(\frac{p_L - (1+\beta)^{-1} p_L^2}{1+\beta-p_L}\right) \left(1 + p_L (1+\beta)^{-1}\right) + p_L L_1 (1+\beta)^{-2} \\
&= \dots \\
&= i_L L_0 \left(\frac{p_L - (1+\beta)^{-1} p_L^2}{1+\beta-p_L}\right) \sum_{j=0}^{n} p_L^j (1+\beta)^{-j} + p_L^{j+1} L_j (1+\beta)^{-(j+1)}.
\end{aligned}$$

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