The Role of the Central Bank, Banks and the Bond Market in the Paradigm of Monetary Analysis

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Zusammenfassung

Als Folge der Finanzkrise 2008/09 sind unter einigen Ökonomen Zweifel an der Adäquanz der theoretischen Modelle aufgekommen, insbesondere über diejenigen, die den Anspruch erheben, Finanzmärkte und Banken zu modellieren. Aufgrund dieser Zweifel folgen einige Ökonomen einer neuen Strömung, indem sie versuchen, ein neues Paradigma zu entwickeln, das auf einer geldwirtschaftlichen anstatt auf einer güterwirtschaftlichen Theorie beruht. Der Hauptunterschied zwischen diesen beiden Sichtweisen ist, dass in einer Güterwirtschaft Geld keine essentielle Rolle spielt, wohingegen bei einer Geldwirtschaft jede Transaktion mit Geld abgewickelt wird. Grundlegend ist es deshalb wichtig zu klären, ob eine Theorie, die Geld miteinschließt, zu anderen Schlussfolgerungen kommt als eine Theorie, die Geld außen vor lässt.

Ausgehend von dieser Problemstellung stelle ich im zweiten Kapitel die Schlussfolgerungen aus der güterwirtschaftlichen Logik des Finanzsystems - modelliert durch die Loanable Funds-Theorie - der geldwirtschaftlichen Logik gegenüber. Dabei kann die Ersparnis, die in der Loanable Funds-Theorie stets mit der Höhe der Investitionen in Sachkapital gleichzusetzen ist, in einer geldwirtschaftlichen Theorie auch lediglich eine Erhöhung/Umschichtung von finanziellen Vermögensgegenständen sein. Des Weiteren bleibt in der güterwirtschaftlichen Logik der Effekt einer höheren Ersparnisbildung auf das Einkommen der Volkswirtschaft unberücksichtigt. So kann eine erhöhte Ersparnis für den Einzelnen durchaus positiv gewertet werden, wenn allerdings jedes Individuum in der Volkswirtschaft die Ersparnis erhöht, ist dies mit einem Konsumrückgang gleichzusetzen, der zu einem sinkenden Einkommen führt. Dieser Effekt bleibt in der Loanable Funds-Theorie unberücksichtigt. Zudem

wird die Loanable Funds-Theorie als Theorie des Finanzsystems beschrieben. Jedoch kann durch die Herleitung der IS-Kurve festgestellt werden, dass die Identität von Ersparnis und Investitionen mit der Identität von aggregiertem Angebot und aggregierter Nachfrage gleichzusetzen ist, wodurch der Gütermarkt dargestellt wird. Im Anschluss an die Überprüfung der Schlussfolgerungen beschreibe ich drei Theorien über Banken: Die erste befasst sich mit Banken und Finanzmärkten im güterwirtschaftlichen Paradigma (sog. Intermediationstheorie). Im Anschluss daran stelle ich zwei Theorien in einer geldwirtschaftlichen Welt dar. Diese unterscheiden sich darin, dass Zentralbanken das Kreditgeschäft der Banken in der sog. Geldmultiplikatortheorie durch Mengen begrenzen, wohingegen in der sog. Geldschöpfungstheorie Zentralbanken die Kreditvergabe der Banken durch Preise steuern. Letztere beschreibt die Bankentheorie, die unsere Welt am besten abbildet.

Ausgehend von dieser Bankentheorie wird im dritten Kapitel ein Modell beschrieben, das die endogene Geldschöpfung berücksichtigt. In diesem Modell handeln die Banken nach einem Gewinnmaximierungskalkül, wobei die Erträge aus dem Kreditgeschäft erzielt werden und Kosten des Kreditausfallrisikos sowie Kosten durch die Refinanzierung (inklusive regulatorischer Vorschriften) enstehen. Hieraus leitet sich das Kreditangebot ab, das auf dem Kreditmarkt auf die Kreditnachfrage trifft. Die Kreditnachfrage wird durch die Kreditnehmer bestimmt, die für Konsumzwecke bzw. Investitionen Kredite bei Banken aufnehmen. Aus dem Zusammenspiel von Kreditangebot und Kreditnachfrage ergibt sich der gleichgewichtige Kreditzins sowie das gleichgewichtige Kreditvolumen, das Banken an Nichtbanken vergeben. Daraus folgend wird über eine feste Multiplikatorbeziehung determiniert, wie viel Zentralbankgeld die Banken nachfragen. Dieses Zentralbankgeld wird den Banken zu einem festen Refinanzierungszins zur Verfügung gestellt. Die Angebots- und Nachfrageseite, die auf dem Kreditmarkt miteinander interagieren, werden ausgehend vom theoretischen Modell empirisch für Deutschland im Zeitraum von 1999-2014 mit Hilfe eines Ungleichgewichtsmodells geschätzt, wobei sich zeigt, dass die Determinanten aus dem theoretischen Modell statistisch signifikant sind. Des Weiteren zeigt sich, dass die Kreditnachfrage zu Beginn des Milleniums die kürzere Marktseite darstellt, was sich durch die schwächelnde Konjunktur in Deutschland erklären lässt. Allerdings wendet sich dieses Blatt in den Jahren vor der Finanzkrise. In dieser Phase kommt es zu einer Kreditexpansion, die durch die Angebotsseite begrenzt wird.

Aufbauend auf dem theoretischen Bankenmodell wird das Modell im vierten Kapitel um den Bondmarkt erweitert. Der Bankenkredit- und der Bondmarkt sind im Gegensatz

zur Beschreibung in der güterwirtschaftlichen Analyse fundamental unterschiedlich. Zum Einen schaffen Banken Geld gemäß der endogenen Geldschöpfungstheorie. Sobald das Geld im Umlauf ist, können Nichtbanken dieses Geld umverteilen, indem sie es entweder für den Güterkauf verwenden oder längerfristig ausleihen. Aufgrund des Fokusses auf das Finanzsystem in dieser Dissertation wird der Fall betrachtet, in dem Geld längerfristig ausgeliehen wird. Das Motiv der Anbieter auf dem Bondmarkt, d.h. derjenigen, die Geld verleihen möchten, ist ähnlich wie bei Banken getrieben von der Gewinnmaximierung. Erträge können die Anbieter durch die Zinsen auf Bonds erwirtschaften. Kosten entstehen durch die Opportunitätskosten der Geldhaltung als Depositen, den Kreditausfall des Schuldners sowie Kursverluste aufgrund von Zinsveränderungen. Die geschilderte Logik basiert auf der Idee, dass Banken Geld schaffen, d.h. Originatoren von Geld sind, und das Geld auf dem Bondmarkt umverteilt wird und somit mehrfache Verwendung findet. Die beiden Märkte sind sowohl angebots- als auch nachfrageseitig miteinander verknüpft. Zum Einen refinanzieren sich Banken auf dem Bondmarkt, um die Fristentransformation, die durch die Kreditvergabe ensteht, zu reduzieren. Des Weiteren haben Kreditnachfrager die Möglichkeit, entweder Bankkredite oder Kredite auf dem Bondmarkt nachzufragen. Dieser Zusammenhang der Märkte wird insbesondere bei der Miteinbeziehung von unkonventioneller Geldpolitik in Form von Quantitative Easing relevant. Bei der Anwendung von Quantitative Easing tritt die Zentralbank als zusätzlicher Anbieter liquider Mittel auf dem Bondmarkt auf und kann dadurch den Zins auf diesem direkt beeinflussen. Die Änderung des Bondzinses hat zwei Effekte auf den Bankenkreditmarkt: Zum Einen können sich Banken günstiger refinanzieren, was zu einer Ausweitung des Kreditangebots der Banken führt. Zum Anderen führt die nachfrageseitige Verknüpfung zu einer Nachfragewanderung hin zur günstigeren Bondmarktfinanzierung, wodurch Preisdruck auf dem Bankenkreditmarkt entsteht. Beide Effekte führen zu sinkenden Zinsen auf dem Bankenkreditmarkt, ausgelöst durch einen Schock auf dem Bondmarkt.
Nach der theoretischen Darstellung des Finanzsystems bestehend aus dem Banken- und Bondmarkt folgt im fünften Kapitel die Anwendung des Modells bei Quantitative Easing. Im Gegensatz zum vierten Kapitel ist festzustellen, dass Quantitative Easing bereits bei der Ankündigung der Zentralbank das Verhalten der Marktakteure beeinflusst, worauf in diesem Kapitel näher eingegangen wird. Die vier großen Zentralbanken (Bank of Japan, Bank of England, Federal Reserve Bank und Europäische Zentralbank) haben aufgrund der anhaltenden Rezession und der bereits niedrigen kurzfristigen Zinsen das unkonventionelle

Instrument des Aufkaufs von Anleihen angewandt. Im theoretischen Modell beeinflusst die Zentralbank bereits durch die Ankündigung die Akteuere auf dem Bondmarkt, sodass es zu sinkenden Risikoprämien, da die Zentralbank als sog. 'lender of confidence' auftritt, zu (zumindest kurzfristig) sinkenden Zinserwartungen sowie insgesamt zu sinkenden langfristigen Zinsen kommt. Diese drei Hypothesen werden anhand empirischer Methoden für die Eurozone überprüft. Hierbei wird festgestellt, dass die Ankündigung zu sinkenden Risikoprämien geführt hat, wohingegen der Effekt auf die Zinserwartungen nicht eindeutig ist. Insgesamt hat die Ankündigung von Quantitative Easing für den Großteil der Ankaufprogramme zu sinkenden langfristigen Zinsen geführt, insbesondere für die Peripherieländer, wohingegen für Deutschland und Frankreich, die von der Finanz- und Wirtschaftskrise weniger stark betroffen waren, der Effekt auf die langfristigen Zinsen nicht eindeutig identifizierbar ist.
Im abschließenden Kapitel werden weitere Forschungsfelder, die im Bereich des monetären Paradigma interessant sind, aufgezeigt.

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List of Abbreviations

a	Saturation amount of credit demand
b	Interest rate elasticity of credit demand
B	Refinancing in the bond market
$\mathbf{B^S}$	supply of funds in the bond market
BM	Reaction function for non-bank suppliers
BoE	Bank of England
BoJ	Bank of Japan
BS	Reaction function for the banking sector
C	Cash
$\mathbf{c_B}$	Credit default costs of banks
$\mathbf{c_{NB}}$	Credit default costs of non-bank suppliers
$\mathbf{Cr_B}$	Credit from banks
$\mathbf{Cr_{CB/B}}$	Credit from central bank to banks
$\mathbf{Cr_B^D}$	Credit demand in the bank credit market
$\mathbf{Cr_{NB}^D}$	Credit demand in the bond market
$\mathbf{Cr_B^S}$	Credit supply from banks
$\mathbf{Cr_{NB}^S}$	Credit supply from non-banks
CBPP	Covered bonds purchase program
CDS	Credit default swaps
CSPP	Corporate sector purchase program
d	Substitution elasticity between the bank credit and the bond market
D	Deposits
E	Refinancing in the equity market
ECB	European Central Bank
ECM	Error correction model
EFSM	European Financial Stabilisation Mechanism
ESM	European Stability Mechanism
fa	Financial assets
Fed	Federal Reserve Bank

$\mathbf{h}$	Cash holding coefficient of the private sector
$\mathbf{H}$	High-powered money
$\mathbf{H^D}$	High-powered money demand
$\mathbf{I}$	Investment
$\mathbf{i_B}$	Interest rate for bank credits
$\mathbf{i_D}$	Interest rate for deposits
$\mathbf{i_E}$	Interest rate for equity
$\mathbf{i_{NB}}$	Interest rate for bonds
$\mathbf{i_R}$	Interest rate for central bank credits
$\mathbf{l}$	Liabilities
LFT	Loanable funds-theory
LPF	Liquidity preference-theory
LTRO	Long-term refinancing operations
$\mathbf{M^D}$	Money demand
$\mathbf{M^{PF}}$	speculative or portfolio demand for money
$\mathbf{M^S}$	Money supply
$\mathbf{M^{SV}}$	money holdings available as a store of value
$\mathbf{m_B}$	Bank credit multiplier
$\mathbf{m}$	Number of non-bank suppliers
$\mathbf{n}$	Number of banks
nfa	Net financial assets
nw	Net worth
$\mathbf{O}$	Operational costs
OMT	Outright monetary transactions
PSPP	Public sector purchase program
SMP	Securities market program
QE	Quantitative Easing
$\mathbf{r}$	Reserve requirement
$\mathbf{R}$	Reserves
$\mathbf{S}$	Saving
ta	Tangible assets
$\mathbf{V}$	Credit risk costs
USA	United States of America
$\mathbf{Y}$	Income
$\mathbf{Y^D}$	Aggregate demand
$\mathbf{Y^S}$	Aggregate supply
$\boldsymbol{\eta}^{\mathbf{B}}$	Ratio of bonds to credit to non-banks
$\boldsymbol{\eta}^{\mathbf{E}}$	Ratio of equity to credit to non-banks
$\boldsymbol{\pi}_{\mathbf{B}}^{\mathbf{j}}$	Profit of bank j
$\boldsymbol{\pi}_{\mathbf{NB}}^{\mathbf{k}}$	Profit of non-bank k

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Chapter 1

Introduction

"Thanks to the crisis, awareness has risen that the most widely used macroeconomic models and finance theories did not provide an adequate description of crucial features of our economies and financial systems, and, most notably, failed to include banks."

(see Werner, 2014)

After the financial crisis, some economists identified oversights in the field of economics, specifically that money and banks, both of which played major roles in the financial crisis, are rarely included in models describing macroeconomics. When addressed in the economic literature, banks are primarily described as pure intermediaries that passively channel funds from savers to investors. In this description, funds are commodities rather than money. However, in contemporary economies, banks do not channel commodities from savers to investors, rather they create money autonomously. Thus, money and banking are interdependent. Since the financial crisis of 2007, this more realistic perspective on banking has gained increasing recognition among economists; meanwhile, central bankers have subscribed to this perspective since the 1920s (see Werner, 2014). In the wake of the financial crisis, some economists have been developing a new paradigm for economics, the so called *monetary paradigm*, which takes the money creation function of banking into account (Borio and Disyatat (2011), Disyatat (2011), Bertocco (2014), Werner (2014) and Jakab and Kumhof (2015)).[1]

In my dissertation, I contribute to this new paradigm of monetary economics by developing a theoretical model which describes the financial system in a monetary economy. The financial system consists of a bond market and a bank credit market, which is connected to the market for high-powered money via the bank credit multiplier. I identify these markets individually because each plays a distinct role in a monetary economy. Specifically, the bank credit market and the bond market both serve special functions in the implementation of unconventional monetary policy measures, which were carried out by central banks in reaction to the financial crisis. In order to empirically validate the theoretical banking model, I use a disequilibrium model to observe the bank credit market for Germany for the sample period 1999-2014. Additionally, I derive hypotheses for the effects of unconventional monetary policy measures based on the theoretical model. These hypotheses are subsequently tested empirically. I find significant effects on sovereign bond yields of euro area countries stemming from announcements of quantitative easing by the European Central Bank (ECB).

Firstly, in Chapter 2, I consider whether models which fail to account for money and banks arrive at fundamentally different conclusions than those models in which they are included, and I describe the path from a real exchange economy (without money) to a monetary economy (with money). On the one hand, Schumpeter (1954) defines the real exchange economy, which he calls real analysis or barter economy, as follows:

> „Real Analysis proceeds from the principle that all the essential phenomena of economic life are capable of being described in terms of goods and services, of decisions about them, and of relations between them. Money enters the picture only in the modest role of a technical device that has been adopted in order to facilitate transactions. (...) But so long as it functions normally, it does not affect the economic process, which behaves in the same way as it would in a barter economy: this is essentially what the concept of Neutral Money implies. Thus, money has been called a 'garb' or 'veil' of the things that really matter, both to households or firms in their everyday practice and to the analyst who observes them. Not only can it be discarded whenever we are analyzing the

[1] Some post Keynesians have also discussed monetary aspects (Fontana, 2003; Lavoie, 2006; Dow, 2007).

> fundamental features of the economic process but it must be discarded just as a veil must be drawn aside if we are to see the face behind it."

In the real analysis, the loanable funds theory (LFT) provides a description of the financial system which is used in many leading textbooks (e.g. Mankiw, 1997; Freixas and Rochet, 2008). The LFT is the model used for the real analysis due to its focus on commodities. Commodities are the funds which are channeled from savers to investors. Thus, commodities represent consumption and investment goods as well as the means of payment and financing.[2]

On the other hand, Schumpeter (1954) outlines the monetary economy as:

> „Monetary Analysis introduces the element of money on the very ground floor of our analytic structure and abandons the idea that all essential features of economic life can be represented by a barter-economy model. Money prices, money incomes, and saving and investment decisions bearing upon these money incomes, no longer appear as expressions-sometimes convenient, sometimes misleading, but always nonessential-of quantities of commodities and services and of exchange ratios between them: they acquire a life and an importance of their own, and it has to be recognized that essential features of the capitalist process may depend upon the 'veil' and that the 'face behind it' is incomplete without it."

The IS-LM Model is based on the monetary analysis; furthermore, the LM curve, which shows equilibria in the money market, is particularly relevant for the monetary analysis. The money market represents the financial system in this model, where money is the means of payment and financing and is separate from consumption and investment goods. I contrast the real analysis with the monetary analysis in order to show that the conclusions from the real analysis do not hold in the monetary economy. First, in the LFT saving is always equal to investment in tangible assets. In a monetary economy, saving can be equal to an increase in either financial assets or tangible assets. Thus, in the LFT, saving is more narrowly defined than it is in a monetary economy. This aspect of the saving definition is derived from the *accounting concept* according to Lindner (2012) and Schmidt (2017). Second, an increase in saving has no effect on income in the LFT. In a

[2]The LFT is used in a key economic debate, namely the decline in long-term interest rates (Rachel and Smith, 2015; Council of Economic Advisors, 2015; Bean et al., 2015; Bofinger and Ries, 2017).

monetary economy, saving has an effect on income via, for example, the *paradox of thrift*. Third, the LFT shows a goods market, whereas in textbooks it is a representation of the financial market. I identify this fact by graphically deriving the *IS curve*. Evaluation of these facts leads to the conclusion that the financial system cannot be assessed via a real analysis. I therefore present the IS-LM model, which includes money via the LM curve, as an adequate framework for the monetary economy. The intersection of the IS curve, which shows equilibria in the goods market, and the LM curve, which depicts equilibria in the money market, determines the interest rate. However, the derivation of the LM curve also reveals some disadvantages with regard to the money supply in the money market. I perform an in-depth analysis of these issues in the description of the *money multiplier theory*. A further focus of the second chapter is the roles of the central bank, banks, and the financial market. I highlight three theories of banking in which a financial market is also indirectly considered (Werner, 2014; Jakab and Kumhof, 2015). First, in the real analysis, banks and the financial market are not fundamentally different from each other from a macroeconomic point of view. Both represent financial intermediaries who transfer funds from savers to investors. However, banks are superior to other intermediaries in an environment of *imperfect capital markets*. Some reasons for this include maturity and quality transformation, monitoring, and screening. Additionally, in a real exchange economy the central bank is not able to control the economy because it cannot produce the commodity which is the essential vehicle. Second, in a monetary economy there exist two theories of banking. In the money multiplier theory, the central bank injects reserves into the banking sector, which in turn is able to multiply the reserves into the money supply. Thus, the money multiplier theory assumes that the central bank follows a quantitative target of reserves in order to regulate the money supply and is able to control the interest rate in the money market indirectly. However, the contemporary practice of central banks is to directly control the price for high-powered money (consisting of reserves and cash), a function which is considered in the *endogenous money creation theory*, which best represents the world we live in (Werner, 2014). In this theory, banks are the creators of money and are not constrained by reserves from the central bank or the saving behavior of households (Disyatat, 2011; McLeay et al., 2014). Money creation refers to the creation of deposits by banks via the granting of credit. However, the banking business is constrained by regulation, profitability, and the behavior of borrowers, as well as the monetary policy rate.

Following the refutation of the real exchange paradigm, in the third chapter I present a model for the bank credit market based on the endogenous money creation theory, in which banks are the providers of money and function as the drivers of economic activity. The theoretical model design assumes profit maximizing banks, where profit is generated by banks' business model, i.e. lending long and borrowing short. Banks' profitability depends on the spread between the lending and the borrowing rates, a condition which is also taken into consideration by post Keynesians (see e.g. Palley, 1996). In addition to profitability constraints, banks' credit creation is limited by regulation and the behavior of borrowers, as well as by monetary policy. In the model, the role of the central bank is twofold. It is the monopolistic supplier of high-powered money and also sets the price for high-powered money, which serves as the lower limit for loan pricing by the banking sector. Here it is worth mentioning that the banking market, as shown in the empirical section of Chapter 3, is determined by prices rather than volumes, a fact which supports the endogenous money creation theory. Banks and the central bank are connected by the multiplier relationship, which determines the amount of central bank credit demanded by the banking sector based on credit granted to non-banks. The market for high-powered money represents the banking sector's demand for high-powered money, dependent on the behavior of the supply and the demand side in the bank credit market. Thus, the causality which underlies the model runs from the asset side to the liability side of the banking sector, which is in line with the endogenous money creation theory. Therefore, in the empirical section of this chapter, a disequilibrium model is applied to estimate the credit supply and credit demand determined in the theoretical model for credit to non-financial corporations in Germany between 1999-2014. The results confirm significance for each determinant. We find that at the start of the millennium, credit demand acted as the restrictive side of the market due to the recessionary environment of the German economy. The German economy recovered in the years preceding the crisis, leading to credit expansion and a shift of the constraining market side from the demand to the supply side.

In Chapter 4, the theoretical model of Chapter 3 is extended to include the bond market. While many economists have considered the bank credit market in the new paradigm of monetary economics, the bond market has been completely neglected. To remedy this, Chapter 4 contributes to the existing literature on endogenous money creation (Disyatat, 2011; McLeay et al., 2014; Werner, 2014; Jakab and Kumhof, 2015; Deutsche Bundesbank, 2017) by first describing the differences between the bond market in a real exchange economy and in a monetary economy. Next, the primary differences between the bank credit market and the bond market in a monetary economy are identified. The bond market is theoretically derived based on stylized facts regarding the supply of and demand for liquid funds in the bond market. The behavior of the supply side is dependent on profitability, which in turn is determined by the interest rate spread between lending liquid funds and holding them as deposits with the bank. Due to the dependence of this spread on the interest rate for deposits, the central bank is able to control the interest rate of bonds because it is assumed that the interest rate for deposits is equal to the refinancing rate at the central bank. In addition, the behavior of the supply side is influenced by credit risk costs as well as future interest rate expectations. The demand side, represented by governments, financial corporations, and non-financial corporations, is able to choose between receiving liquid funds from either the bank credit market or the bond market. Thus, a substitution relationship exists between the two markets. Furthermore, the two markets are interconnected due to the fact that banks refinance a part of their business in the bond market; they do so in order to reduce the maturity mismatch in their balance sheets which results from their business model of lending long and borrowing short. The bond market in particular should be considered because quantitative easing works via the bond market. Central banks act as additional suppliers of liquid funds in the bond market and in this way are able to directly control long-term bond yields. Consideration of the substitution elasticity, which can be interpreted as the intensity of competition between the bond market and the bank credit market, allows for the assessment of quantitative easing spillover effects in the bank credit market. The decline in bond yields also leads to a decline in bank credit interest rates due to cheaper refinancing for banks in the bond market and the threat that banks may otherwise lose borrowers.

Chapter 5 presents the in-depth application of the model of the financial system to the quantitative easing of the European Central Bank. After the financial crisis, the ECB expanded its monetary policy instruments to include unconventional measures such as quantitative easing and liquidity support measures, without any theoretical foundation. Chapter 5 contributes to the primarily empirical literature analyzing unconventional policy by providing a theoretical foundation as well as a comprehensive empirical assessment of all quantitative easing measures carried out by the ECB. In our model, both of the previously mentioned monetary policy instruments have effects on the bank credit and bond markets. Liquidity support measures were intended to provide banks with liquidity via long-term refinancing opportunities. With this instrument, banks were able to decrease their maturity mismatch via central bank refinancing, a cheaper alternative to maturity matched refinancing in the bond market. Following this shift to a cheaper source of refinancing, the refinancing costs of the banking sector decreased, resulting in declining bank interest rates. The ECB additionally acted as a direct supplier of liquidity in the bond market, where it purchased bank, government, and corporate bonds via the programs of quantitative easing. Other conditions held equal, this leads to an increase in supply in the bond market and thus to a decrease in bond yields. However, due to forward looking agents in the bond market, it may be assumed that these agents have already priced in the effects of QE on any given announcement day. Thus, in our model the announcement effect of QE influences the behavior of the suppliers of liquid funds in the bond market via two channels: the credit risk and the interest rate expectation. After credit risk spread skyrocketed during the financial crisis, the ECB acted as a lender of confidence, leading to a decrease in credit risk.[3] Additionally, suppliers of liquidity in the bond market could expect lower interest rates as a result of QE. Chapter 5 empirically assesses these hypotheses. When applying an error correction model, we find negative, significant effects of the announcements of QE on 5-year sovereign bond yields for Germany, France, Portugal, Spain, Italy, Ireland, and the euro area, a result which supports our hypothesis of decreasing bond yields. In a further step, we apply an event based regression to analyze the credit risk and interest rate expectations channels. The credit risk channel is confirmed by our empirical analysis, indicating that the ECB acted as a lender of confidence in order to converge the previously diverged sovereign bond yields in the euro area. The hypothesis of lower interest rate expectations - measured according to term premia - cannot be unequivocally confirmed by the data. We suppose this to be due to a diminishing effect of interest rate expectations occurring during the course of the announcement day which is in line with the literature analyzing intraday data.

In the final chapter, I discuss further research areas which should be addressed in order to develop a comprehensive model for the monetary paradigm.

[3]This result has been empirically confirmed by Szczerbowicz (2015), Gerlach-Kristen (2015), and Falagiarda and Reitz (2015).

Chapter 2

From the Real exchange Economy to the Monetary Economy

2.1 Introduction

Since the financial crisis, awareness of the need to rethink standard economic models has risen. In particular, concerns about depicting the financial system via economic models have been voiced within the economic profession (Bertocco, 2009, 2011; Disyatat, 2011; Lindner, 2012, 2013; Spahn, 2013; Werner, 2014; Jakab and Kumhof, 2015).

A primary criticism is directed towards the loanable funds theory (LFT). This theory stems from a model of the financial system in which either banks or other intermediaries channel funds from savers to investors. The theory is used to explain the decline of long-term interest rates (Rachel and Smith, 2015; Council of Economic Advisors, 2015; Bean et al., 2015). According to these studies, demographic factors are considered to be the primary determinants for an increase in the propensity to save, which subsequently leads to a decline in long-term interest rates. If a model such as the loanable funds theory is intended to explain the decline in long-term interest rates, this model should realistically assess the financial system.

In order to address this issue, I detail the path from the real exchange economy, for which the LFT is an appropriate framework, to a monetary economy. The real exchange paradigm is characterized by a world where commodities are used as means of payment and a store of wealth. Each transaction comprises an exchange of goods for goods. In a monetary economy, on the other hand, the exchanges are conducted via the interchange of goods or financial claims for money.[1] In a first step, I show that conclusions drawn from the LFT do not necessarily hold for a monetary economy. For instance, saving are always equal to investment in a real exchange economy, where no financial assets exists. However, in a monetary economy, saving can also consist of the redistribution of financial assets. This distinction is highlighted by the accounting concept. Additionally, saving negatively influences income in a monetary economy. In contrast, in the real exchange economy higher saving has no effect on income. Basically, as stated in the economic literature, the LFT represents a goods market where aggregate supply is equal to aggregate demand and no financial market is present.

After identifying the saving-investment-identity as goods market-equilibrium, I derive the IS curve, which depicts equilibria of saving and investment for different levels of income. In order to take the financial system into account, I present the LM curve, which is derived from the money market. In the money market, either the central bank determines the supply of money directly, or a banking sector is interposed which increases the amount of high-powered money provided by the central bank to the money supply. The equlibria for different levels of income in the money market are connected to the LM curve showing a positive relationship between income and interest rate. Thus, the IS-LM model can be understood as a macroeconomic model for a monetary economy which has some drawbacks with regard to the money market, in particular concerning the money supply process.

I describe these disadvantages in more detail following a description of banking theory in the real exchange economy (intermediation theory). In the intermediation theory, banks and financial markets coexist and the differences between the two stem from microeconomic factors such as the reduction of transaction costs and information asymmetry. The money multiplier theory represents a banking model for a monetary economy. As previously mentioned, there exist some downsides to the contemporary world application of the money multiplier theory. For one, the central bank controls prices, but no quantitative targets. Additionally, banks' behavior is not restricted via the injection of high-powered money.

[1] The term money refers to fiat money, which plays an integral role in the contemporary world.

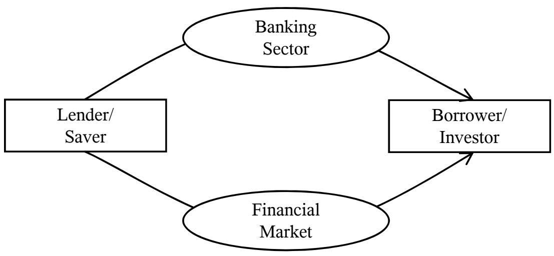
Rather, it is constrained by monetary policy (controlling the refinancing rate), profitability, credit and liquidity, risk, equity requirements, and the behavior of borrowers. These constraints are addressed in the endogenous money creation theory, which is discussed in the latter part of this chapter. Section 2.5 summarizes the chapter's main points.

2.2 The Loanable Funds Theory

The financial system in the real exchange economy is described by the 'loanable funds theory' which was primarily developed by Wicksell (1936), Robertson (1934) and Ohlin (1937).

The real exchange logic of the LFT becomes obvious in the standard presentation of the financial system that can be found in many leading textbooks (Mankiw, 1997; Freixas and Rochet, 2008). The source of financial flows is the household sector, which abstains from consumption in order to save. In the LFT there exists a unique physical good (e.g. a commodity) which is used as a consumption and an investment good as well as a means of financing and payment. The unique good is channeled via either the financial market or the banking sector to borrowers, who invest the saving. The flow of funds starts with the saver. The funds are directed to an investor via intermediaries, at which point the process is complete. Thus, the standard presentation of the flow of funds (see Figure 2.1) is characterized by a one-way flow without any circulation.

Figure 2.1: Flow of funds in the real exchange economy



The LFT explains the functioning of financial markets according to this simple illustration of financial flows. The theory describes the flow equilibrium of saving and investment, which is shown in Figure 2.2.

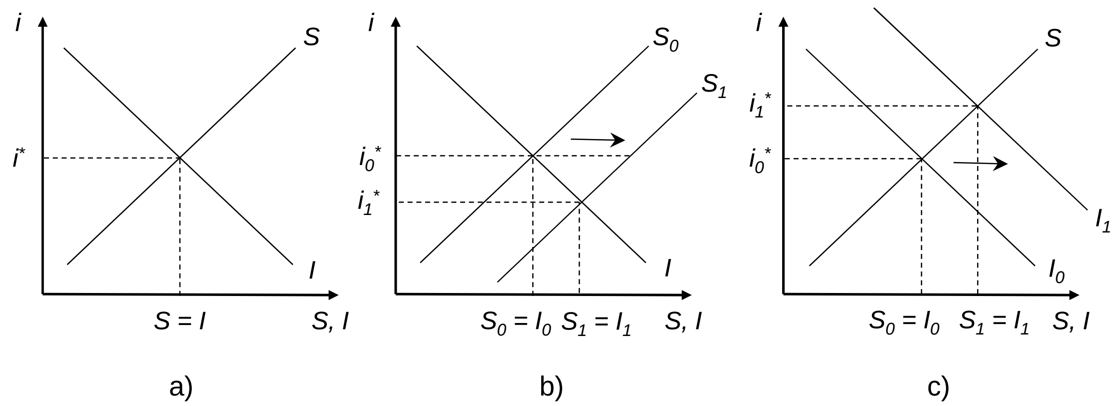
The supply of loanable funds in one period is identical to the amount of planned saving in the same period. Households' decision to save depends on their time preference, which is the value of future consumption in comparison with that of current consumption. The supply curve is upward sloping due to the assumption that the substitution effect dominates the income effect.

The demand for funds in one period is identical to the amount of planned investment in this period. The investment decisions of firms are based on the productivity of such investment. If the interest rate decreases, more investors are willing to invest.

The intersection of saving and investment reveals the equilibrium interest rate, which is a real interest rate. The equilibrium interest rate reflects the time preferences of savers, who must be willing to give up consumption goods, and the productivity of investment.

Graphically, I illustrate the supply of and demand for funds, as well as the equilibrium between these two which determines the equilibrium interest rate in Figure 2.2a. If saving increases, i.e. because of a lower time preference of savers, the supply schedule shifts to the right. The excess of saving over investment at the prevailing interest rate leads to a decline in the interest rate. In the new equilibrium, saving and investment is higher than in the old equilibrium (see Figure 2.2b). Following an increase in investment due to higher productivity, the investment curve shifts to the right, resulting in higher saving and investment as well as a higher interest rate (see Figure 2.2c).

Figure 2.2: Loanable Funds Theory



To sum up, the process of financing in the LFT is characterized by the exchange of goods today for goods tomorrow. The interest rate for financing represents the price to abstain from consumption today in exchange for consumption tomorrow.

2.2.1 Accounting concept

In this section, I use the accounting concept to assess, for a monetary economy, the conclusion that saving is always equal to investment (Lindner, 2012, 2013; Schmidt, 2017).

The accounting concept is based on double accounting standards, which are used in the

business sector but can also be applied to economics. According to double accounting standards, it is assumed that two parties are involved in each executed transaction.
First, we examine a balance sheet of one individual:

Table 2.1: Simplified balance sheet

Assets	Liabilites
Tangible Assets ta	Net worth nw
Financial assets fa	Liabilities l

According to the double accounting method, assets are equal to liabilities. Assets consist of tangible assets and financial assets (money and other financial assets such as bonds, loans, and equity). On the liability side, net worth and liabilities are reported.

$$\text{Assets} = \text{Liabilities}$$
$$\mathrm{ta} + \mathrm{fa} = \mathrm{nw} + \mathrm{l}$$

In order to solve for net worth, I rearrange the balance sheet equation and receive

$$\mathrm{nw} = \mathrm{ta} + \mathrm{fa} - \mathrm{l} \tag{2.1}$$
$$\mathrm{nw} = \mathrm{ta} + \mathrm{nfa}.$$

An individual can hold net worth either as tangible assets or net financial assets nfa, the latter of which is the difference of financial assets and liabilities. Assuming there are two individuals, the nfa of the individual who represents a surplus unit ($nfa > 0$) has to match the nfa of the other individual's deficit unit ($nfa < 0$). If one grants credit to another, double accounting entails that the lender records a claim against the borrower and the borrower a liability against the lender. On a consolidated basis, the nfa of the borrower is equal to the nfa of the lender.
Following the analysis for individuals, I apply the concept of accounting to sectors (households, non-financial corporations, financial corporations, governments, and rest of the world) (Koo, 2011). The same relationships which are valid for individuals are valid for sectors. The net financial assets of one sector must be equal to the net financial liabilities of another sector. For example, if sector j has positive net financial assets, they have to be matched by negative net financial assets of the other sectors $j - 1$.

$$nfa_j = -nfa_{j-1}$$

Moving from the stock concept to the flow concept, we take the first difference of Equation 2.1:

$$\Delta nw = s = \Delta ta + \Delta nfa,$$

where saving s is equal to a change in net worth. An agent has the opportunity to save by increasing either tangible or net financial assets.

The meanings of saving

Saving has four different possible meanings for an individual according to Schmidt (2017). In order to avoid confusion, I present these meanings here.

1. Increase in net worth

   An economic agent is able to increase their net worth if they consume less than income received in a given period. As seen in Table 2.1, this increase in net worth is achievable via an increase in either tangible or financial assets.

2. Increase in net financial assets

   As with an increase in net worth, an increase in net financial assets is also a result of consuming less than total income for a given period. But in contrast to net worth, net financial assets exclude tangible assets. Thus, an increase in net financial assets can be explained by an increase in financial assets -i.e. granting credit to another economic unit- or a decrease in liabilities -i.e. paying off outstanding credit.

3. Decrease in consumption

   This concept comprises two time periods, where in the more recent period the economic agent has consumed less than in the previous one.

4. Shift to long-term assets

   Alternatively to the second case, financial assets can also be reclassified, meaning that someone who has made short-term investments on the asset side restructures the asset side in such a way that they transform the short-term investments to long-term ones. This differs from the second explanation in that shifting existing assets arises from a stock concept, whereas the second explanation describes a flow concept. Furthermore, the shift to long-term assets can also include tangible assets.

The change in tangible assets is per definition equal to investment i:

$$\Delta nw = s = i + \Delta nfa$$

As previously mentioned, the net financial assets of one sector are matched by the net financial liabilities of the other sectors. E.g., if one sector grants credit to another sector, the financial assets of the first sector increase and the liabilities of the other increase, resulting in a zero sum-game. This situation leads to the result that for the total economy or a closed economy, net financial assets equal zero:

$$0 = \sum_{j=1}^{N}(nfa_j).$$

Summing the change in tangible assets, net worth, and net financial assets across all sectors N, we obtain the result for the total economy that saving is equal to investment:

$$\begin{aligned}\sum_{j=0}^{N}(s_j) &= \sum_{j=0}^{N}(\Delta nfa_j + i_j)\\ S &= \Delta NFA + I = 0 + I\\ S &= I.\end{aligned}$$

In conclusion, at the individual and sectoral levels, saving means either the redistribution of financial assets or an increase in tangible assets, whereas at the level of the total economy saving always means an increase in tangible assets which is equal to investment.

In a real exchange economy, where no financial assets or liabilities exist due to the commodity character, saving is always identical to investment. In the monetary economy, on the other hand, saving can also be attributed to the redistribution of financial assets.

2.2.2 Paradox of thrift

A further conclusion of the LFT is that higher saving has no effect on income. The LFT assumes a given income which households allocate to consumption and saving, whereby saving is transferred to investors who invest these funds. However, Keynes ([1930] 1971b) showed that if each agent decides to save more, a reduction in income can be observed in a monetary economy.

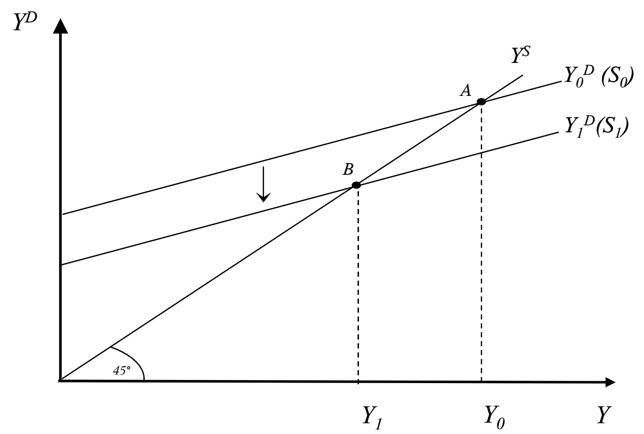
Whereas for an individual or sector higher saving is beneficial, for the overall economy higher saving produces a negative effect on income. This phenomenon is known as the *paradox of thrift*, which Keynes ([1930] 1971b) explains as follows:

„For although the amount of his own saving is unlikely to have any significant influence on his own income, the reactions of the amount of his consumption on the incomes of others makes it impossible for all individuals simultaneously to save any given sums. Every such attempt to save more by reducing consumption will so affect incomes that the attempt necessarily defeats itself. It is, of course, just as impossible for the community as a whole to save less than the amount of current investment, since the attempt to do so will necessarily raise incomes to a level at which the sums which individuals choose to save add up to a figure exactly equal to the amount of investment.“(Keynes, [1930] 1971b, p.84)

In the Keynesian description of the paradox of thrift, higher saving leads to the previously mentioned negative effect on income. The Keynesian cross, which represents a goods market, is able to highlight this effect graphically (see Figure 2.3).

The aggregate demand curve Y_D is determined by consumption and investment for a closed economy without a fiscal sector, where consumption depends on income Y and investment on the interest rate i. The aggregate supply curve Y_S is assumed to extend in a 45°-line, which means that supply adjusts immediately to changes in demand. Starting from point A, representing a cleared goods market, an increase in saving which is identical to a decrease in consumption leads to a parallel downward shift of the aggregate demand curve ($Y_0^D \rightarrow Y_1^D$). At point B- the new equilibrium- a lower level of income is realized due to an increase in saving.

Figure 2.3: Paradox of thrift

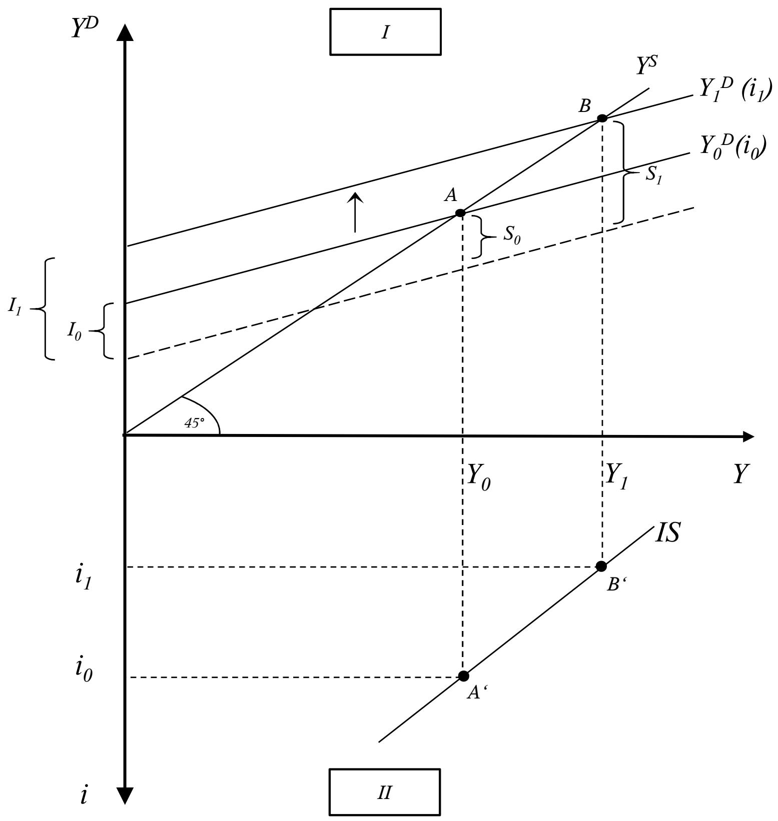


Thus, saving has a negative feedback effect on income in a monetary economy, which is not addressed in the LFT.

2.2.3 Goods vs. financial market

A further point which must be addressed is that the LFT describes a goods market rather than a financial market. I differentiate between these two markets in the IS-LM model, in which the IS curve depicts multiple equilibria in the goods market. The IS- curve is derived from the Keynesian cross (see Figure 2.4, first quadrant). Starting with a cleared goods market in the Keynesian cross, meaning aggregate demand Y_0^D is equal to aggregate supply Y^S, an associated income Y_0 is obtained for a predetermined interest rate i_0 (point A). At point A, saving S_0 is equal to investment I_0. Changing the interest rate results in a shift in the aggregate demand curve. For example, with a decrease in the interest rate, resulting in an increase in investment, the aggregate demand shifts upwards ($Y_0^D \rightarrow Y_1^D$). With a constant aggregate supply, I obtain a further combination of income (Y_1) and interest rate (i_1), where saving S_1 is also equal to investment I_1. These combinations are illustrated in an income/interest rate diagram (Figure 2.4, second quadrant), where the IS curve is established by connecting points A' and B'.

Figure 2.4: IS curve



Thus the IS curve, which shows equilibria of saving and investment, also represents the equilibria of aggregate supply and aggregate demand. A goods market is depicted and a financial market is unaccounted for. The standalone concept of the IS curve does not facilitate the ascertainment of an interest rate equilibrium for the economy. Meanwhile, in the IS-LM model the determination of the interest rate depends on the reaction of the central bank, which controls the money supply in this model.

2.3 The monetary economy logic of the LM curve

A simple and established framework for understanding the monetary economy is the LM curve. The LM curve places the money market into a macroeconomic framework.
There are two methods for derivation of the LM curve, and for the money supply in particular. In one approach, it is assumed that the central bank determines the money supply and in this way indirectly controls the interest rate. Thus, this approach does not consider a banking sector since this sector has no explicit function if the provision of money is carried out by the central bank.[2] Another interpretation of the LM curve is based on the idea that the central bank determines a fixed amount of high-powered money which the banking system is able to multiply to the money supply.[3] However, both versions assume a money supply which is interest rate insensitive. Thus, for the derivation of the LM curve there exists no difference between these two interpretations of the money supply. The counterpart to the supply side is the agents who demand money based on the following three motives:

- Transaction motive (M_t)
  In a monetary economy in which money is the means of payment, each agent requires money for each transaction. It is assumed that for an increase in income, economic agents execute more transactions, which leads to an increase in the demand for money.

- Speculative motive (M_s)
  The speculative motive is a result of the function of money as a store of wealth. An individual decides to hold wealth either as money or bonds. In the case of bonds, there exists an inverse relationship between the price of bonds and the interest rate of bonds. If the demand for bonds increases (demand for money decreases), the price

[2] Money is defined here as cash, which is often termed M_0.
[3] A more detailed description of this money supply process can be found in Chapter 2.4.2.

of bonds rises and the interest rate decreases. In the money demand theory, each individual has an estimate for a critical interest rate value, according to which they will hold either money or bonds. The critical values differ between the individuals. Hence, for each individual I ascertain a combination of money demand and interest rate which can be aggregated to a negatively sloped money demand curve. The speculative motive induces a negative correlation between the interest rate and money demand.

- Precautionary motive (M_p)

  The precautionary motive describes the demand for money for unexpected events. The precautionary demand for money is presupposed to depend on the interest rate and income. Its relationship to income is the same as that of the transaction motive, and to the interest rate as that of the speculative motive.

In addition to the previously mentioned motives for money demand, a discussion about money demand for financing activities arose following the publication of Keynes ([1930] 1971a). As a result of this discussion, Keynes extended the money demand concept to include the finance motive.

- Finance motive (M_f)

  The temporary demand for money due to the finance motive arises because of the time lag between an investment decision and the act of investment (Keynes, 1937). Liquidity is a prerequisite for an entrepreneur who is willing to invest. According to Keynes (1937, p.248):

  > „For 'finance' constitutes, as we have seen, an additional demand for liquid cash in exchange for a deferred claim.“[4]

  In order to construct the finance motive, Keynes distinguishes between the investment rate which leads to additional demand for money and one which does not. If the investment rate is constant, the investment can be financed by revolving funds, which do not increase money demand. There is an increase in the credit volume but not in the money stock. Money is merely circulated for the purpose of transactions in the economy. However, if the investment rate increases, there is a corresponding increase in money demand because the new investments cannot be financed by the

[4] The 'deferred claim' can be either bonds or bank credits.

> constant money stock. Hence, there must be either a reaction by the money supply or an effect on the interest rate. It is crucial to distinguish between the different investment rates in the economy. Otherwise, a change in the investment rate always leads to an interest rate adjustment. Thus, the money demand due to the finance motive depends on income in the same way as does the transaction motive.

Hence, the money demand equation looks like:

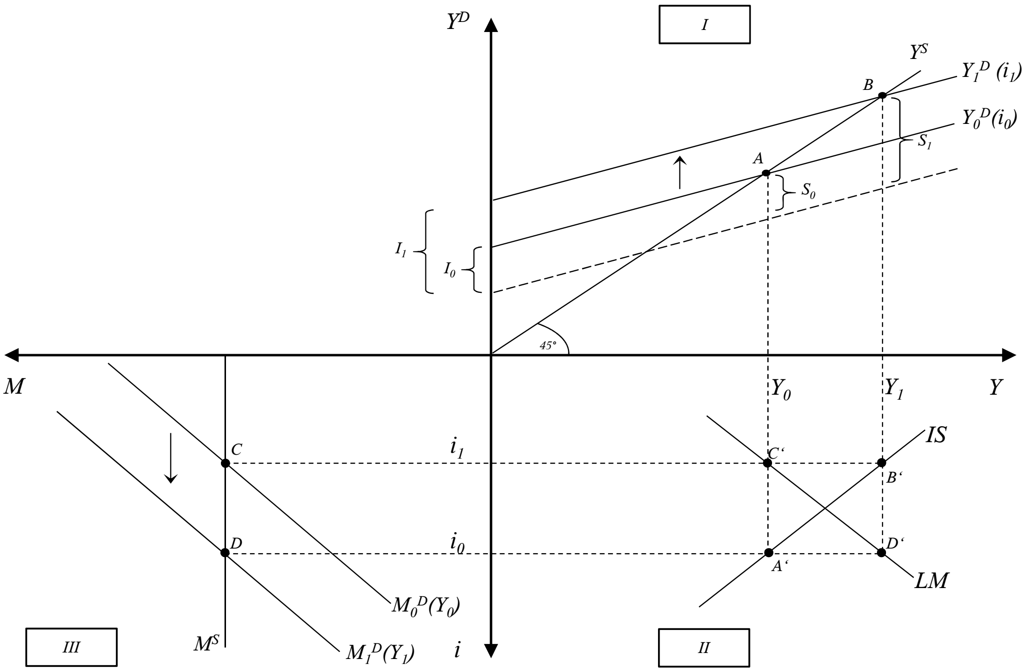
$$M^D(Y;i) = M_t \underbrace{(Y)}_{+} + M_p \underbrace{(Y;i)}_{+;-} + M_s \underbrace{(i)}_{-} + M_f \underbrace{(Y)}_{+}.$$

Following the derivation of the money demand function, the money market equilibrium is described as the equality of money supply M^S and money demand M^D

$$M^S = M^D(Y;i).$$

Based on the money market equilibrium, I derive the LM curve, which shows the equilibria in the money market for different levels of income Y in the third quadrant of Figure 2.5. If income increases ($Y_0 \to Y_1$), economic agents are more willing to consume, which leads to an increase in transactions for which money is used. Hence, money demand increases ($M_0^D \to M_1^D$), and agents have to sell bonds in order to obtain money. The effect of shifting from bonds to money implies a reduction in the value of bonds, leading to an increase in the interest rate given a constant money supply ($i_1 \to i_0$). Reflecting points C and D, which represent equilibria in the money market, into the second quadrant enables us to draw the positively sloped LM curve by connecting points C' and D'.

Figure 2.5: LM curve

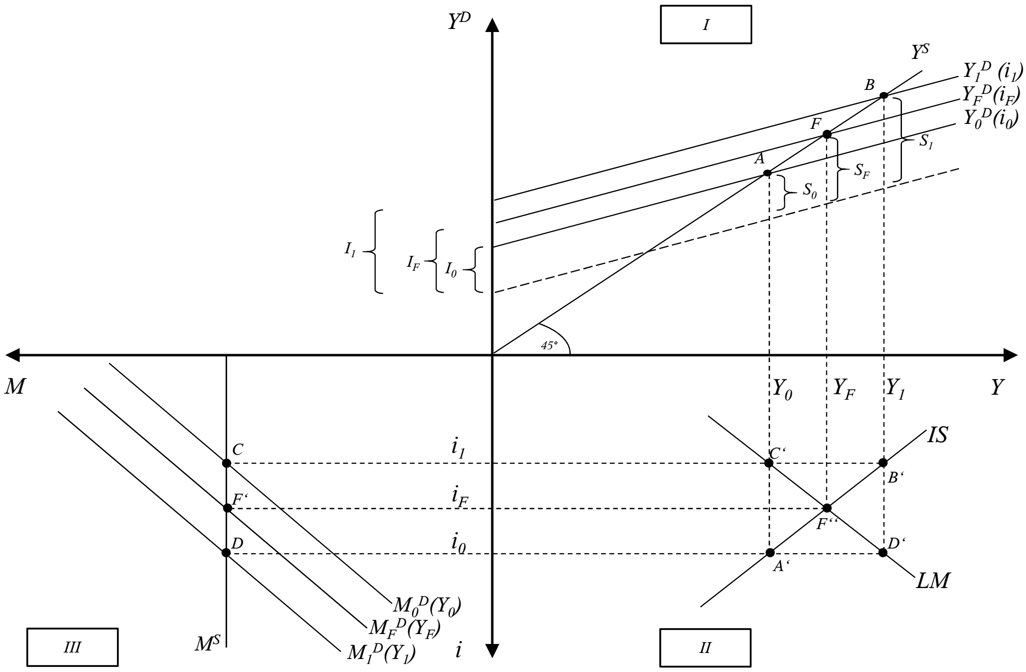


Turning to the second quadrant, we examine the IS-LM model. The IS curve represents flow equilibria on the goods market which are derived from the first quadrant. The LM curve depicts stock equilibria in the money market which are derived from the third quadrant. In addition, we obtain a new equilibrium at the intersection of the IS-LM model, shown as point F" in Figure 2.6.

This equilibrium represents the interaction between the goods and money markets. At point F", the goods and money markets are simultaneously in equilibrium. The central bank is able to control the interest rate of the economy by directing the money supply. For instance, if a decline in consumption in the goods market is observed, income decreases, negatively affecting the money demand. This leads, ceteris paribus, to a decline in the interest rate. In order to stabilize income, the central bank may intervene in the money market and is able to reduce the interest rate by increasing the money supply.

Thus, in contradistinction to the real exchange logic, the equality of saving and investment corresponds to a goods market rather than a financial market. The financial market is modeled by the equilibria in the money market. Additionally, in the IS-LM framework, the central bank is able to influence economic activity via its control of the money supply, thereby affecting the interest rate.

Figure 2.6: IS-LM model



2.4 Three views on the financial system

In this section, I describe three theories of the financial system. One of them addresses the financial system in the real exchange economy and the others deal with the monetary economy.

As discussed in Chapter 2.2, banks and financial markets fulfill the same function, which is the transfer of saving to investors in a real exchange economy. In a first step, I briefly describe the roles of the central bank, banks, and financial market in the real exchange economy. Next, I shift the focus to the monetary economy. I outline the money multiplier theory, which is the description of the money supply process. Finally, the theory of banking, which is the most appropriate theory for addressing contemporary world conditions, is presented as the endogenous money creation theory.

2.4.1 Intermediation theory

In the LFT, both, the banking sector and the financial market are intermediaries of loanable funds, where loanable funds are commodities. The flow mechanism is depicted in Figure 2.1. Savers have to abstain from consumption in order to lend commodities to investors. The flow can either be transfered by banks or by other financial intermediaries. In a macroeconomic sense, there is no difference between these two types of intermediaries. Both actors transfer the unique good from savers to investors. Thus, the differentiation of their roles must be based on a microeconomic perspective.[5]

In perfect capital markets, choosing to channel funds from savers to investors either directly (via banks) or indirectly (via other intermediaries) does not matter. However, introducing transaction costs and/or information asymmetry leads to various differences between banks and other intermediaries.

Information asymmetry between lenders and borrowers can be eliminated by banks, which assume the function of monitoring and screening borrowers. In addition to this role, banks are able to transform assets with regard to quality and maturity (reduction in transaction costs). Quality transformation refers to the fact that a small investor is not able to independently diversify their portfolio, but a bank may do so due to its size. Maturity transformation occurs when banks collect short-term deposits and subsequently transform them into long-term loans. The transformation argument regarding the reduction of transaction costs is based on economies of scale in the banking industry. Furthermore, given the opportunity to monitor and screen borrowers, banks are able to manage risks, e.g. credit or market risks. These functions of banks highlight the advantages of banks compared with other financial intermediaries.

In the real exchange economy, there exists, in principle, no explicit role for a central bank that stabilizes the financial system. As it is unable to produce commodities (the input factor for the financial system), the central bank possesses no genuine instrument to regulate the quantity of commodities.

In summary, from a macroeconomic perspective there is no distinction between financial markets and banks. We find differences in the context of imperfect capital markets, where transaction costs and/or information asymmetry lead to the difference between banks and financial markets.

2.4.2 Money multiplier theory

The money market, where two versions of the money supply process exist, offers one opportunity for modeling the financial system in a monetary economy.

As mentioned at the beginning of Section 2.3, one approach to the money supply does

[5] This Chapter 2.4.1 is based on Freixas and Rochet (2008).

not take a banking sector into account. However, in textbooks, we mainly find the money multiplier theory, which describes the money supply process with banks included. The difference between these two is the fact that the first approach does not incorporate a banking sector, whereas in the money multiplier theory a banking sector is included. However, in the money multiplier theory, banks' behavior is not described, because the money multiplier is simply a balance sheet mechanism. The money multiplier theory assumes that the central bank provides high-powered money, which banks are able to multiply to the money supply. Hence, credit creation by banks is constrained by central bank's provision of high-powered money.

The idea behind the money multiplier theory is based on a balance sheet mechanism. As with non-financial corporations, the banking business is assumed to function as follows: banks must first finance their business, i.e. demand credit from the central bank, and subsequently invest these funds, which entails the granting of credit to non-banks. In terms of the money multiplier theory, banks multiply high-powered money H to money supply M:

$$M = m \times H, \tag{2.2}$$

where m represents the money multiplier.

Supposing that money consists of cash C and deposits D and high-powered money consists of cash C and reserves R, we insert these elements into Equation 2.2:

$$C + D = m \times (C + R).$$

Solving this equation for the money multiplier m gives us

$$m = \frac{C + D}{C + R}.$$

Furthermore, we assume that cash is determined as a fraction h of deposits, where h is the cash holding coefficient of the public. In addition, the central bank requires a fixed amount of deposits as reserves to be kept as reserves expressed as fraction r of deposits.

Including this in the previous equation, we obtain

$$m = \frac{1 + h}{h + r}.$$

The money multiplier is determined by the cash holdings of the public as well as the reserve requirements of the central bank. Assuming the values h and r are less than one, the money multiplier is larger than one.

The central bank is able to control the money supply by selling or purchasing bonds to or from banks in the open market, and in this way provides high-powered money. An increase in the money supply is described as an expansionary monetary policy and decrease as a restrictive monetary policy.

As described in Section 2.3, the counterpart to money supply is money demand. The demand side has the option of holding their wealth either as money or as bonds. This means that an increase in money demand is equal to a decline in demand for bonds, because the interest rate immediately adjusts in such a way that money and bonds holdings are rebalanced (Walras' Law).

In conclusion, the money multiplier theory describes a causal effect running from the central bank to the money supply, where the central bank determines the amount of money supplied to non-banks. Thus, the money supply process described here assumes that the mechanism underlying this process is equivalent to the behavior of banks. Prices do not play a role in determining the behavior of banks in this theory, resulting in an interest insensitive money supply function. The assumption of an interest inelastic money supply curve and the logic that the central bank determines the money supply are misleading in the world we live in.[6] Postkeynesians' economists discuss the money supply process in the dispute between the horizontalists and structuralists (Fontana, 2003; Lavoie, 2006; Dow, 2007). Their contribution to the literature is the argument that banks are not constrained by reserves as described in the money multiplier theory, and this leads us to the more realistic theory of endogenous money creation.

2.4.3 Endogenous money creation theory

The endogenous money creation theory was initiated by postkeynesians (as e.g. Fontana (2003), Lavoie (2006), Dow (2007)) as well as other economists, above all Werner (2014) and McLeay et al. (2014).

Werner (2014) performed an empirical experiment in order to answer the question of whether banks are constrained by reserves. This experiment shows that banks can create loans endogenously, a result which supports this theory as being the most realistic.[7] Endogenous means, in this context, that the granting of credit by banks is not restricted by reserves or saving.

[6] For an empirical analysis of the abandonment of the money multiplier theory, see Disyatat (2011) and Carpenter and Demiralp (2012).

[7] Disyatat (2011) also provides support for this result.

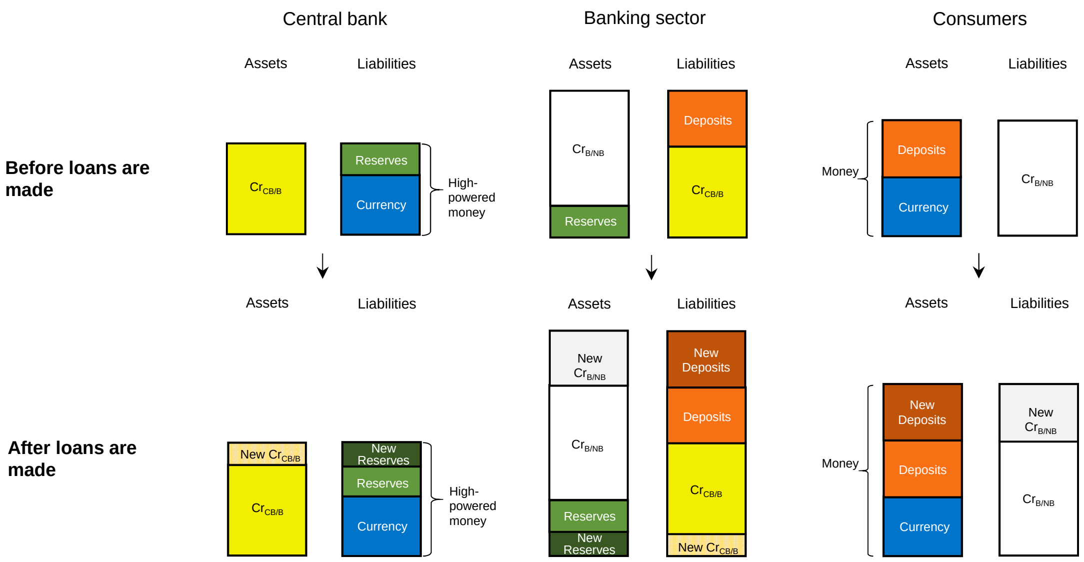
The process of money creation

In the previously discussed money multiplier theory, credit is equal to money. However, in the context of the actual banking business there exists a difference between credit and money. Prior to the explanation of money creation, the difference between money and credit must be clarified. Money is a concept of the liability side of the banking sector which is dependent on the maturity of the items on the liability side. Depending on the relevant central bank's definition of what constitutes money, the maturity of 'money' may range up to two years. All items which do not fit into the definition of money are considered non-money items, which predominantly consist of bonds and equity. Credit is a concept of the asset side of the banking sector. If credit is refinanced with money (deposits), credit creation is equal to money creation. Otherwise, credit creation is not associated with money creation.

The description of the money creation process is based on McLeay et al. (2014). Assuming that each instance of credit is matched by deposits, in the interest of simplicity I assume that each act of credit creation is also an act of money creation.

The economy consists of three sectors: a central bank, the banking sector and, consumers. In Figure 2.7, the conditions 'before loans are made' represent the initial situation. The central bank's balance sheet consists of credit from the central bank to banks $Cr_{CB/B}$ on the asset side and of reserves and currency on the liability side. Currency and reserves are referred to as high-powered money, or monetary base. The credit from the central bank to banks is recorded on the liability side of the banking sector. In the initial situation, consumers hold deposits at the bank. On the asset side, the banking sector records the credit from banks to non-banks $Cr_{B/NB}$ as well as reserves held by the central bank. Meanwhile, the asset side of the consumers consists of deposits and currency. On the liability side, consumers record credit received from the banking sector.

Figure 2.7: Money Creation



Source: McLeay et al. (2014), author's illustration.

The situation 'after loans are made' is a result of credit creation by banks. The banking sector initiates credit creation. Through the act of lending, new deposits are credited to the accounts of the consumers. In other words, the balance sheet of the banking sector as well as that of the consumers is expanded by the amount of credit granted (New $Cr_{B/NB}$). At the same time, the banking sector is required to hold a fixed proportion of new deposits as reserves. Therefore, the banking sector demands credit from the central bank in order to meet the reserve requirements. „This demand for base money is therefore more likely to be a consequence rather than a cause of banks making loans and creating broad money"(McLeay et al., 2014, p.8). The central bank has a special position from the perspective of money creation. The central bank acts as the monopolistic supplier of high-powered money. Due to this status, the central bank is able to effectively control the process of credit creation, albeit in an indirect way. As the central bank can set the price for high-powered money (its policy rate), and this can be regarded as an input factor for the creation of loans, it can indirectly influence the interest rate for bank loans. As McLeay et al. (2014, p.8) put it:

> „Central banks do not typically choose a quantity of reserves to bring about the desired short-term interest rate. Rather, they focus on prices- setting interest rates."

The policy rate also exerts a more direct influence on bank lending. It sets a lower limit for the money market rate (e.g. EONIA), i.e. the rate at which an individual bank can obtain central bank liquidity from other banks. Furthermore, this rate sets a starting point for the rates that banks pay for short-term deposits. Thus, one constraint on bank lending is monetary policy, but this occurs via prices rather than quantities.
In addition to monetary policy, the profitability of banks, liquidity and credit risks, and equity requirements, as well as the behavior of borrowers, are also constraints on the banking sector.

- Profitability

  In a competitive market, only those banks which adopt a profitable business model survive. The business model of banks is to borrow short and lend long. A spread exists between the long lending rate and the short borrowing rate which facilitates the generation of profits and the payment of operational costs.

- Liquidity and credit risks

  One component of operational costs is the costs for liquidity and credit risks. The liquidity risk is a result of the business model of lending long and borrowing short. If one bank experiences a drain of deposits without securing refinancing in the interbank market, liquidity concerns arise. Therefore, banks restructure their liability side in order to reduce the maturity mismatch which occurs between the asset and liability side. They issue long-term bonds which they exchange for deposits on the liability side.

  Banks additionally face credit risk. Credit risk refers to the risk of failure on part of the borrower. If a borrower is not able to repay a loan, the bank has to depreciate the loan which in turn generates costs.

- Equity requirements

  Due to the risks faced by the banking sector, banks have to be able to absorb losses. Thus, equity requirements are introduced by regulators in order to reduce the risk of a bank failure.

- Behavior of borrowers

  In addition to the role of the supply side in influencing bank lending, the demand side - represented by borrowers - is also able to strengthen or weaken bank lending activities. Newly created money can be used either for circulation in the economy, where goods or financial assets are purchased, or for the redemption of outstanding debt. In the latter case, such money is immediately removed.[8]

2.4.4 Summary

Different perspectives in the central bank

In the intermediation theory, a central bank does not perform any role because it cannot produce the commodity which is used to finance investments. In this theory a central bank is therefore obsolete.

In contrast, the theories of a monetary economy include the central bank. However, each theory identifies a different role of the central bank. In the money multiplier theory, the central bank provides money and indirectly controls the interest rate in the money market via influencing the money supply.

The endogenous money theory, which best addresses contemporary world conditions, assumes the central bank to be a price setter for central bank credit. The central bank controls the short-term refinancing rate, which is a primary determinant of the credit creation process of the banking sector.

Thus, while in the money multiplier theory the central bank controls the volume of money, in the endogenous money theory the central bank sets prices directly.

Different perspectives of banks

In a monetary economy, the role of banks extends far beyond the intermediation function attributed to them by the real exchange paradigm.

In the model of the real exchange economy, banks can only create loans if they have received an inflow of a commodity. The means of financing is a commodity which the banks cannot produce.

In the money multiplier theory, banks are constrained by reserves which are determined by the central bank. Thus, the causality runs from the liability to the asset side.

In the endogenous money creation theory, the situation is completely different. In this world, bank deposits can only be created via bank loans. This even applies to the creation of bank deposits via depositing cash directly into a bank account. Currency in circulation

[8] A more detailed description of this process can be found in Chapter 4.

has to be created via the refinancing of banks by the central bank. Thus, currency creation is the result of a loan made by the central bank.

In contrast to the LFT, where banks can only determine the distribution of a given flow of loanable funds, in a monetary economy banks are the source of loanable funds. Thus, banks play a dominant role in a monetary economy. Above all, banks provide the financing for investments independently of current saving or reserves. Along with investors who demand bank loans, banks control the flow of investment, which is decisive for the business cycle.

Different perspectives of financial markets

Whereas in the real exchange economy the financial market cannot be distinguished from banks which transfer funds, in the monetary economy the actors in the financial market redistribute the money created by banks. Thus they are fundamentally different from banks, which create money.

In the money multiplier theory, financial markets (i.e. bond market) are the reflection of the money market according to Walras' law. The monetary framework of the endogenous money creation theory rarely deals with the financial market. In the literature dealing with a monetary framework, Disyatat (2011) (p.712) briefly refers to the financial market:

> „Moreover the same underlying mechanism should apply to nonbank intermediaries, broadening the potential importance of this channel to nondespository institutions that may nonetheless play an integral part in the transmission mechanism."

In conclusion, the financial market, where huge volumes are traded, is not explicitly considered in the endogenous money creation theory. Therefore, in Chapter 4 I develop a new perspective of financial markets, and of bond markets in particular. According to this view, banks add money to the bond market which is redistributed and in this way changes hands multiple times.

2.5 Conclusion

In this chapter, I described the path from a real exchange economy to a monetary economy in order to provide a more accurate picture of the world we actually live in. In order to derive a model for the monetary economy based on the endogenous money creation theory, I describe the behavior of the actors representing the supply and demand sides. I address this topic further in the following two chapters. In Chapter 3, I provide insight into the functioning of the banking market, and in Chapter 4 I take a closer look at the bond market.

Additionally, the investigation of the monetary economy reveals two empirical issues. As previously discussed, the real exchange logic is an inappropriate framework for the monetary economy, because the conclusions of the real exchange logic does not entirely hold in the monetary economy. Therefore, the discussion about the decline in long-term interest rates since the 1980s must be challenged by a monetary approach (see Bofinger and Ries (2017)). The second issue, which arose following the financial crisis, is the mechanism of QE. In a real exchange economy, the central bank cannot affect the economy. However, in a monetary economy, the central bank is able to influence the banking activities as well as the financial market via the short-term refinancing rate. Additionally, the central bank is able to purchase bonds in the bond market and in this way is able to control the long-term interest rate as well (quantitative easing). This aspect will be empirically addressed for the Eurozone in Chapter 5.

Chapter 3

A Model of the Market for Bank Credit: The Case of Germany[1]

3.1 Introduction

We present a basic model that illustrates the process of credit creation in a monetary economy. In our model, credit is determined by the interaction of three sectors: banks, non-banks and the central bank. The model features two markets: the market for bank credit and, connected by a multiplier relation, the market for high-powered money. In a first step, credit volume is determined by supply and demand in the market for bank credit and, in a second step, banks demand a fraction of the credit volume in form of high-powered money from the central bank. This modeling design of banks is much closer to banks' daily business practice. As a fact, banks do not need a specific amount of reserves or pre-collected savings beforehand in order to extend credit. When a bank makes a loan, it simply credits the customer's account with a bank deposit equal to the size of the loan (McLeay et al., 2014). This introduces, in contrast to the predominant view of banks as intermediaries, the idea of banks as creators of credit.

In addition to presenting our model, we push our analysis further and verify the veracity of

[1] This chapter is based on joint work with Peter Bofinger and Daniel Maas.

our model by estimating a credit market. More precisely, we estimate the German market for firm credit from January 1999 until December 2014, where demand and supply factors are chosen on the basis of our theoretic model. On account of information imperfections on credit markets (Stiglitz and Weiss, 1981) and disturbances emanating from other sectors of the economy, it is unlikely that supply and demand in the market for bank loans are equal at every point in time. We take this feature into account by analyzing the credit market in a disequilibrium framework estimated with bayesian methods. Beyond evaluating our theoretic model, the disequilibrium framework also allows us to identify episodes in the German credit market that were characterized by demand or supply overhang.

Figure 3.1 displays the evolution of the credit to non-financial firms and self-employed people and real GDP growth during our sample period. Unsurprisingly, the evolution of credit is closely linked to the business cycle, where GDP growth seems to lead movements in credit. Focusing on the evolution of real GDP growth, Germany experienced a short recovery at the beginning of our sample, between 1999 and 2001, before entering a recessionary phase that lasted until 2005/2006. Then, for a short period, the German economy accelerated until the financial crisis erupted in 2007/2008. Whereas other European countries struggled to recover from the financial crisis, Germany bounced back relatively quickly and regained its pre-crisis GDP level from the first quarter of 2008 in the first quarter of 2011.

Figure 3.1: Bank credit to non-financial corporations and self-employed people and real GDP growth

Source: Bundesbank and OECD.

Moving on to the development of credit, the short economic recovery around 1999 and 2000 is reflected by an increase in credit. Credit peaked locally in the first quarter of 2002 with a credit volume of approximately 800 million euros, before a decline set in that went on until late 2005. The negative credit growth fell in a period where Germany performed poorly in economic terms which led the incumbent government to reform the welfare system and the labor market (Agenda 2010). From 2006 until the crisis, credit exploded and increased from 730 million to 840 million euros in the first quarter of 2009. Then, in 2009, Germany's bank credit market for firms experienced a strong drop in credit growth. The financial crisis that had started in the U.S. had finally spilled over to Europe. The crisis increased the uncertainty about counter-party risks among banks which resulted into a freeze of the interbank market. The fear of a melt-down of the financial system with devastating consequences for the real economy led the ECB to take, in addition to standard monetary easing measures, non-standard measures to protect the functioning of the financial system. As liquidity dried up in funding markets, the ECB introduced liquidity and funding measures like the long-term refinancing operations (LTROs) and purchased assets in malfunctioning market segments, e.g., Covered Bonds Purchase Program (CBPP). On the national level, the German government ensured the banks' solvency with guarantees and supported aggregate demand with an economic stimulus plan in 2009.

Applying the disequilibrium model to the German market for firm credit, we are able to capture the economic episodes in Germany fairly well. Our model predicts that at the beginning of the millennium credit demand, i.e. the firm sector, was lagging behind credit supply which coincides with the recessionary environment of the German economy at that time. Thereafter, during the run-up to the crisis and afterwards, credit supply, i.e., the banking sector, was the constraining market side and prevented a stronger credit expansion. Our results are supported on a microeconomic level. The Kredithürde of the ifo-institute, which reflects the borrowing conditions of German firms, indicates worsening credit conditions after the financial crisis. This result is confirmed by Rottmann and Wollmershäuser (2013). They develop a bank credit supply indicator, based on the responses by firms from the Ifo Business Survey, which suggests a tightening of credit supply after the crisis.

Furthermore, the regression results confirm the relevance of our model's main determinants. Our model motivates a role for economic activity and for various funding costs of banks and firms, which includes lending rates, bond rates and the refinancing rate. Quantitatively and qualitatively, we find plausible and significant results for the factors determining credit supply and demand. Our contribution extends into several dimensions. First, we present an aggregate model of the market for bank loans, where banks back their credit business with a variety of refinancing sources. This includes in addition to refinancing via the central bank and deposits, the bond market and equity market. Second, in our model, the logical order places banks' credit business in front of refinancing operations, which is the adequate description of banking today. Third, we estimate a market for German firm credit in a disequilibrium framework and, in addition to testing our model, identify episodes of excess demand and supply in the loan market. And fourth, we show that the evolution of bank credit can be well captured with prices which gives support to the price-theoretic approach of our model.[2]

The paper is organized as follows. Section 2 contains an overview of related literature. Section 3 illustrates the theoretic model for the banking sector. Section 4 discusses our econometric approach and section 5 provides the estimation results. Section 6 concludes.

3.2 Literature Review

Our theoretic model builds on the work by Bofinger and Schächter (1995). Close to this model design is the work of Winker (1996) who also models an aggregate market for bank loans where banks behave as profit-maximizing firms (Freixas and Rochet, 2008). Most importantly, our model design is consistent with the view of banks as creators of credit, in contrast to the mainstream view of banks as intermediaries of credit. In short, intermediary banks lend out funds that they collected before making the loan.[3] This assumes that some entity in the economy has put funds, that can be lent out, to disposition by, e.g., saving more. In contrast, viewing banks as creators of credit reverses causality: making a loan creates, as a balance sheet reflex, deposits on the bank's liability side. Therefore, the extension of credit depends on the willingness of banks to loan money and not on the abstinence of some household epitomized by saving more. The misconception of seeing saving as the source or prerequisite for expenses of any sort is strengthened further by a misinterpretation of the savings-investment identity. The identity is interpreted causally, where causality runs from saving to investment. However, it is not higher saving that is needed for funding new investments but rather additional financing possibilities. A

[2]Price-theoretic means that it is not quantities, such as deposits and equity, that play the leading role in extending credit but rather differentials in prices.

[3]This is the correct description, of course, for financial institutions other than banks.

deeper digression into the difference between saving and financing is provided by Borio and Disyatat (2011, 2015) and Lindner (2012). Therefore, since banks are able to make loans by pure will, their credit business is not constrained or relaxed by pre-collected savings or reserves.[4] Causality goes in reverse order: in a first step, the bank makes a loan and, in a second step, the necessary reserves are procured after credit business has taken place. Our model describes this process accurately by placing credit business in first place. Werner (2014) actually proves that this is the way banks do business, by carrying out a field experiment that documents this practice. Making a distinction between the two models of banking is not only of mere academic interest. Disyatat (2008, 2011) underlines that the understanding of how banks function and the modeling of banks impact policy implications in an important way. Finally, Jakab and Kumhof (2015) contribute to this area of research by developing a state-of-the-art DSGE-model that includes banks as creators of credit, instead of intermediaries, and illustrate the implications of the modeling choice of banks in the framework of a DSGE-model. As an aside, it is stunning that these insights were well known among economists and central bankers from the early 20th century, but did not get incorporated into mainstream economics.[5]

The empirical study and estimation of markets for bank loans started in the early 1970s. In the beginning, markets were estimated by assuming them to be in equilibrium, but as evidence on the possibility of credit rationing accumulated, economists adopted the disequilibrium framework. In this case, demand and supply do not even each other out at every instant of time and one market force prevails over the other. Therefore, both sides of the market, demand and supply, are analyzed separately. An early work represents Laffont and Garcia (1977) who estimate a disequilibrium model for the supply and demand of chartered banks' loans to business firms in Canada. Building on their work and on others, the disequilibrium approach became a standard tool for answering questions relating to the credit market, which resulted into a broad body of work.[6] Among recent studies that apply the disequilibrium framework is Everaert et al. (2015). They study countries in Central, Eastern and Southeastern Europe which experienced a credit boom-bust cycle in the last decade. Their goal is to find out whether demand or supply factors were the

[4]This does not mean that banks serve every demand for credit. Banks have to survive in a competitive environment where bad decisions push them out of the business.

[5]Jakab and Kumhof (2015) list many statements from central bankers and economists of the early 20th century that describe banks as creators of credit. In academia, this view was pursued vigorously only outside of mainstream. See, e.g., Lavoie (1984); Asimakopulos (1986); Davidson (1986) and Palley (1996).

[6]A non-exhaustive list is: Ito and Ueda (1981); King (1986); Kugler (1987); Martin (1990), and Pazarbasioglu (1997).

more important driving forces during this period. For Latvia, Poland and Romania, they find constraints on the credit demand side for the period from 2003 to 2012. In contrast, Lithuania and Montenegro seemed to be the object of changing demand and supply regimes. Especially after crisis events, scholars studied the question whether economic conditions were aggravated further by a shortage in credit supply, i.e., a credit crunch. In particular, the financial crisis of 2007 incurred heavy strains in banking sectors that probably led banks to curb the supply of credit. Reznakova and Kapounek (2014), for example, test for a credit crunch of the Czech credit market after the financial crisis. They conclude that the decrease in credit after the crisis can be related to low economic and investment activity which rejects the hypothesis of a credit crunch. Vouldis (2015) analyzes the Greek credit market on a disaggregated level (short- and long-term business loans, consumer loans and mortgages) between 2003 and 2011. He finds that during the boom before the crash, demand for credit exceeded the supply of credit and as the debt crisis intensified, constraints on the supply side led to a decrease in credit.

Turning to Germany, several authors studied the German credit market for episodes of disequilibrium and credit crunches. Beginning with Nehls and Schmidt (2003), they study loans to enterprises and self-employed workers in the period from 1980 until 2002. On the supply side they distinguish between an aggregated banking sector and different banking groups. The authors find evidence for excess credit demand in 2002. Especially the behavior of big banks contributed to supply constraints of aggregate credit. Boysen-Hogrefe et al. (2010) modify the model of Nehls and Schmidt (2003) and estimate a coefficient-varying disequilibrium model for loan supply and demand for non-financial corporations between 1970 and 2009. In addition, they evaluate what effects a change in equity regulations would imply for the development of credit. Furthermore, they examine the effect of credit growth on economic growth. Contributing to research on supply side shortages of credit during the financial crisis, Erdogan (2010) analyzes the German market for bank credit from 1991 until 2009 for non-financial corporations. She finds that a liquidity injection into the German banking system at the end of 2008 helped to overcome supply constraints in Germany. Schmidt and Zwick (2012) support her findings. Additionally, Schmidt and Zwick (2012) update their earlier model (Nehls and Schmidt (2003)) for different banking groups between 1990 and 2011 with the result that banks with high impairments during the financial crisis cut their supply more than the others.

3.3 A simple model for the banking market

We introduce a model for the credit market which builds on Bofinger and Schächter (1995). The model provides a framework to analyze the process of credit creation in a bank-based economy. The model features two markets, the market for bank loans and the market for high-powered money, which are linked by a multiplier relation. On the market for bank loans, banks provide credit that the non-banking sector uses for finance. By setting the refinancing rate for banks, the central bank influences the banks' funding costs and, therefore, has a direct effect on the supply of credit. The interaction of credit demand and supply in the market for bank loans yields the equilibrium quantity of credit and price, i.e., the market rate for credit. Banks then need to acquire a fraction of their granted credit, pinned down by the multiplier, in form of central bank money in the market for high-powered money. In the market for high-powered money, the central bank acts as the sole supplier of base money and meets the banks' demand for central bank money at a fixed price (refinancing rate).

Extending the model in Bofinger and Schächter (1995), banks have a richer set of refinancing instruments at their hands to fund their credit business. This includes, in addition to deposits and credit from the central bank, the issuance of bonds and holdings of equity. Expanding the set of financial instruments makes a distinction between the two monetary aggregates, money and credit, reasonable. The defining characteristic between the two is their maturity structure as bank liabilities. Whereas money is short-term debt and held in form of deposits at the banks' account, credit includes also longer-term debt such as equity and bonds.

The next steps include a presentation of each market and their participants.

3.3.1 Credit Market

Supply of bank loans

The model follows an industrial-organization approach which is characterized by profit maximization of each bank. Banks do so by choosing the amount of credit that maximizes their profit. The asset side of the bank's balance sheet reveals the revenues from credit business and the liability side, which consists of the refinancing sources of banks (equity, bonds, deposits and central bank credit), exposes the refinancing costs (see Table 3.1).[7]

[7]The balance sheets of all sectors are presented in Appendix Tables 3.3 - 3.5.

Taking into account all revenues and costs, the profit function for one representative bank j is equal to:

$$\pi_B^j = i_B Cr_{B/NB}^j - i_D D^j - i_R(Cr_{CB/B}^j - R^j) - i_E E^j - i_{NB} B^j - O^j - V_B^j,$$
$$\text{with } V_B^j = c_B \times (Cr_{B/NB}^j)^2.$$

The revenue $i_B Cr_{B/NB}^j$ stems from the credit business. $Cr_{B/NB}^j$ denotes the credit from banks to non-banks, which is provided at the bank interest rate of i_B. The costs associated with the credit business are the sum of the interest paid on deposits $i_D D$, the net refinancing from the Central bank $i_R(Cr_{CB/B} - R)$, equity costs $i_E E$, refinancing at the bond market $i_{NB} B$, operational costs O and credit risk costs V_B.[8] According to Fuhrmann (1987), Cosimano (1988), Freixas and Rochet (2008), we assume that the credit risk costs increase disproportionately in the amount of credit. The component c_B depends positively on the credit default probability and negatively on income. The operational costs consist of, among others, screening and monitoring. The balance sheet of one representative bank reads as follows:

Table 3.1: Bank's balance sheet

Assets	Liabilites
Credit from Banks to Non-banks $Cr_{B/NB}$ Reserves R	Equity E Bonds B Deposits D Credit from Central Bank to Banks $Cr_{CB/B}$

Banks refinance their business via equity, bonds, deposits and credit from the central bank. They use these funds for granting credit and holding minimum reserves at the central bank. To simplify the profit function, we take the balance sheet identity of a bank and substitute:

$$Cr_{CB/B}^j - R^j = Cr_{B/NB}^j - D^j - E^j - B^j. \tag{3.1}$$

Furthermore, we assume that a fixed proportion of bank credit to the non-banking sector is backed by equity, as it is required in the Basel Regulations. An additional fraction of credit is hold in form of bonds which serves the reduction of interest rate risk. Interest rate risk emanates from the maturity mismatch between assets and liabilities on the bank's

[8] The characteristics of V_B ensure a concave profit function with a unique optimum.

balance sheet. Thus, we set:

$$\eta^E = \frac{E^j}{Cr^j_{B/NB}} \quad \text{and}$$
$$\eta^B = \frac{B^j}{Cr^j_{B/NB}}.$$

Substituting η^E, η^B and (3.1) into the profit function, we get:

$$\pi^j_B = (i_B - i_R - \eta^E(i_E - i_R) - \eta^B(i_{NB} - i_R))Cr^j_{B/NB} - (i_D - i_R)D^j - O^j - c_B(Cr^j_{B/NB})^2.$$

For deriving the optimal credit supply of one representative bank, we take the first-order condition of the profit function with respect to the credit volume, $Cr^j_{B/NB}$, which yields:

$$Cr^j_{B/NB} = \frac{(i_B - i_R) - \eta^E(i_E - i_R) - \eta^B(i_{NB} - i_R)}{2c_B}.$$

Assuming that there are n identical banks, total credit supply is equal to:

$$Cr^S_{B/NB} = \sum_{j=1}^{n} Cr^j_{B/NB} = \frac{[(i_B - i_R) - \eta^E(i_E - i_R) - \eta^B(i_{NB} - i_R)]n}{2c_B}. \tag{3.2}$$

Demand for bank loans

Each sector (public and private) demands credit in order to invest or consume. We model income and the cost for credit as key determinants of our credit demand. Additionally, the possibility to choose between different types of financing affects credit demand. This might not be the case for households and small and medium-sized enterprises which obtain their financing only via banks, but larger enterprises might choose the type of financing that suits their needs best. This possibly includes going to the bond market.[9] Hence, we introduce substiutability between different sources of financing according to Singh and Vives (1984), Wied-Nebbeling (1997), Ledvina and Sircar (2011). These considerations motivate the following form for the demand of bank loans:

$$Cr^D_B = a - bi_B + d(i_{NB} - i_B), \tag{3.3}$$
$$\text{with } a = \mu + \gamma Y.$$

The demand for bank credit depends negatively on the interest rate for bank credit, i_B, and positively on income, Y, and on the price differential of the two credit categories, bonds and bank credit, $(i_{NB} - i_B)$.

[9]We assume a homogeneous bond market and therefore banks and non-banks face the same bond rate.

According to Ledvina and Sircar (2011), the substitutability implies three different relationships between the market for bank credit and bonds:

- independent loans $d = 0$: The price differential between bank credit and bonds does not influence the demand for bank credit.
- differentiated loans $d \in (0, \infty)$: The price differential between bank credit and bonds does influence the demand for bank credit.
- homogeneous loans/perfect substitutes $d \to \infty$: The two types of financing are perfect substitutes. Hence, theoretically, if there is a price difference between the two credit categories, the sector which offers the lowest price serves the whole demand.

In an institutional sense, the banking sector is a key driver of economic activity due to the function as the supplier of money. The bond market operates on top of the banking sector by intermediating financial claims that the banking sector has created before. Therefore, in a sense, the bank credit market is a prerequisite for the bond market.

Equilibrium

The market for bank loans is in equilibrium if the supply of bank loans (equation (3.2)) is equal to the demand for bank loans (equation (3.3)).[10] Hence, we get the following equilibrium credit volume and interest rate:

$$Cr^*_{B/NB} = \frac{a - (b+d)(i_R + \eta^E(i_E - i_R) + \eta^B(i_{NB} - i_R))}{1 + 2c_B(b+d)},$$

$$i^*_B = \frac{2c_B(a + di_{NB}) + (i_R + \eta^E(i_E - i_R) + \eta^B(i_{NB} - i_R))}{1 + 2c_B(b+d)}.$$

3.3.2 Bank credit multiplier

After the derivation of the equilibrium amount of credit in the banking market, we are interested in the amount of high-powered money that corresponds to this credit volume. In economic textbooks, the relation of money to high-powered money is called the money multiplier. However, the multiplier in our model is not to be confounded with the common textbook money multiplier. Here, the bank credit multiplier, m_B, which extends beyond the standard money multiplier by including a wider array of refinancing instruments, is

[10] Here, for simplifying matters, we set the number of banks, n, equal to one.

defined as the ratio of credit from banks to non-banks, $Cr_{B/NB}$, to high-powered money, H:

$$m_B = \frac{Cr_{B/NB}}{H}.$$

By making use of the following equality:

$$Cr_{B/NB} = \frac{M}{1 - \eta^E - \eta^B},$$

and the fact that money, M, consists of cash, C, and deposits, D:

$$M = C + D,$$

as well as that high-powered money, H, includes cash, C, and reserves, R:

$$H = C + R,$$

the bank credit multiplier can be written as:

$$m_B = \frac{Cr_{B/NB}}{H} = \left(\frac{C + D}{C + R}\right)\left(\frac{1}{1 - \eta^E - \eta^B}\right).$$

Additionally, we suppose that the public holds a fixed proportion of deposits in cash:

$$C = h \times D,$$

where h is the cash holding coefficient of the public.
Furthermore, the banking sector is obliged to hold reserves as a fraction of deposits:

$$R = r \times D,$$

where r is the minimum reserve requirements determined by the central bank.
Including all these facts in the bank credit multiplier equation, we get:

$$m_B = \frac{Cr_{B/NB}}{H} = \underbrace{\left(\frac{1 + h}{h + r}\right)}_{\text{(A)}}\underbrace{\left(\frac{1}{1 - \eta^E - \eta^B}\right)}_{\text{(B)}}.$$

The first ratio, (A), is the standard money multiplier, which is larger than one. The second ratio, (B), is also larger than one, because $\eta^E + \eta^B < 1$, resulting in a bank credit multiplier larger than one. If the banking system increases the ratio of leverage from the non-banking system, η^B, or the equity financing, η^E, the bank credit multiplier increases. Hence, for the same amount of bank credit less high-powered money is required.

Given the bank credit multiplier, m_B, and the equilibrium amount of credit, $Cr^*_{B/NB}$, we derive the optimum amount of high-powered money demanded by banks as:

$$H^* = \frac{Cr^*_{B/NB}}{m_B}. \tag{3.4}$$

At this point, we would like to emphasize an important distinction. The interpretation of our multiplier is diametrically opposed to the interpretation of the multiplier in standard economic textbooks. Therein, the money supply process starts with the central bank injecting a specific amount of high-powered money into the banking system which then, by the multiplier process, generates a quantity of money that surpasses the initial base money injection by a factor larger than one. However, this modeling approach does not capture adequately the mechanism of endogenous money creation by the banking sector (Werner, 2014; McLeay et al., 2014). Consistent with the endogenous money theory, our model incorporates this feature where causality runs from money to high-powered money. That means, it is the banking sector that acts first by extending credit and, in a second step, the central bank provides the high-powered money, determined by the multiplier relation, that the banking sector demands. This order of causation is expressed in equation (3.4), where the equilibrium amount of high-powered money is a function of credit and the multiplier.

3.3.3 Market for high-powered money

The role of the central bank is two-fold in this model. On the one hand it sets the refinancing rate, and on the other hand it provides high-powered money as a monopolistic supplier. The central bank provides as much high-powered money as the banking sector demands for a fixed price (refinancing interest rate, i_R), that it sets.

The demand for high-powered money can be considered as a function of bank credit. If there is no equilibrium amount of credit at the market for bank credit, banks have no incentive to demand high-powered money. Hence, the prohibitive price for bank credit minus the spread for equity and bond refinancing, e in equation (3.5), is equal to the prohibitive price for high-powered money.

Assuming a linear demand function for high-powered money, H^D, we derive its slope by connecting two points on the demand schedule (saturation quantity and quantity at reservation price).

Thus, we obtain the following demand function for high-powered money:

$$H^D = \frac{Cr^*_{B/NB}}{m_B} - \frac{Cr^*_{B/NB}}{m_B \times e} i_R, \tag{3.5}$$

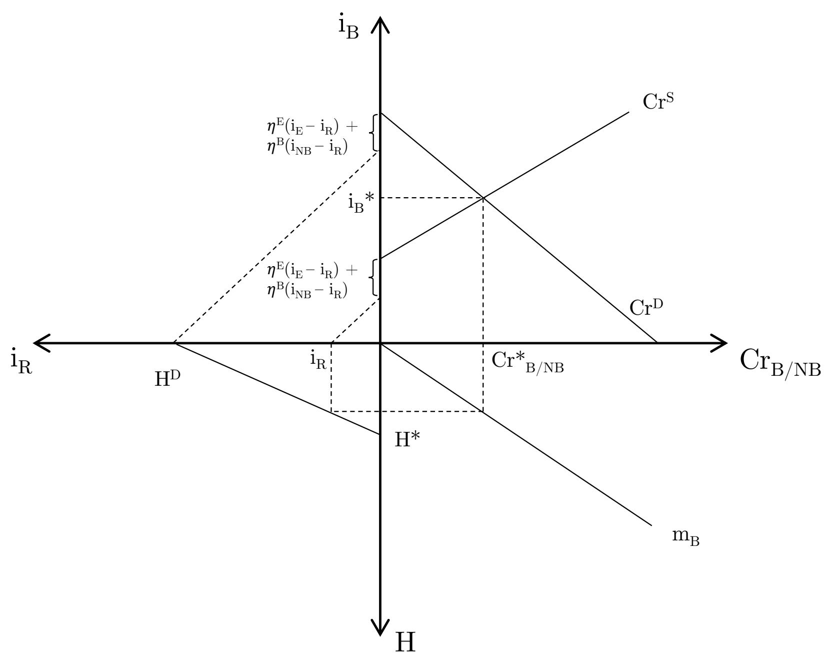
$$\text{with } e = \left(\frac{a + di_{NB}}{b+d}\right) - \eta^E(i_E - i_R) - \eta^B(i_{NB} - i_R). \tag{3.6}$$

Banks' demand for high-powered money is determined by the optimal credit volume, the multiplier relation, the prohibitive price as well as the refinancing rate set by the central bank. This determination is in line with causality running from credit to high-powered money.

3.3.4 Graphical illustration

Figure 3.2 shows a graphical representation of the model, which also highlights the connection between the two markets. By choosing the refinancing rate, the central bank sets the intercept of the credit supply curve. The refinancing costs at the equity market as well as at the bond market shift the supply curve upwards by increasing the intercept. The intersection between credit demand and supply determines the interest rate and amount of bank credit in equilibrium. Via the bank credit multiplier, we obtain the amount of high-powered money at a fixed refinancing rate.

Figure 3.2: Complete model of the credit market with all sectors: banks, non-banks and central bank



3.4 Empirics

We estimate a credit market with explanatory variables chosen on the basis of our theoretic model. To take into account the specifics of a credit market, like the information structure (Stiglitz and Weiss, 1981), we estimate a disequilibrium model. Stiglitz and Weiss (1981) motivated the case for disequilibria in the credit market where non-clearing lending rates are based on information-theoretic arguments. Financial contracts are especially subject to information asymmetries such that banks might set interest rates below the clearing market rate. The reason for this is that increasing the market rate has two effects. First, good borrowers drop out of the market (adverse selection) and, second, borrowers are likely to undertake riskier projects (moral hazard), thereby increasing default costs. As a consequence, market rates are not consistent with the market-clearing rate which leaves one market side constrained.

The empirical model for estimating a disequilibrium model takes the following form:

$$d_t = x'_{1t}\beta_1 + u_{1t}, \tag{3.7a}$$

$$s_t = x'_{2t}\beta_2 + u_{2t}, \tag{3.7b}$$

$$q_t = \min(x'_{1t}\beta_1 + u_{1t}, x'_{2t}\beta_2 + u_{2t}). \tag{3.7c}$$

d_t and s_t represent the notional demand and supply for credit. β_1 and β_2 are the slope parameters for demand and supply, respectively. x_{1t} is a $(k_1 \times 1)$ vector and x_{2t} is a $(k_2 \times 1)$ vector of explanatory variables for d_t and s_t, respectively. Obviously, identification is only possible if the two explanatory vectors differ in at least one co-variate.

$u_{1t} \sim N(0, \sigma_1)$ and $u_{2t} \sim N(0, \sigma_2)$ are error terms and independent of each other which allows for different supply and demand variances. The observed credit volume, q_t, is set equal to the minimum of the two market sides, where the other side of the market remains unobserved.

The model consists of the demand equation, (3.7a), supply equation, (3.7b), and one minimum condition, (3.7c), which allocates observed credit, q_t, to the demand or the supply side. The specification in equation (3.7c) includes demand and supply disturbances inside the min condition and, therefore, introduces a stochastic regime selection. Alternatively, it is possible to leave out the error terms and obtain a deterministic regime selection, where an error term is added outside the min condition to capture observational errors. We retain the model with stochastic regime selection because from an economic perspective it is more reasonable that demand and supply shocks determine, by including them into the min condition, which market side is operational. Ultimately, the min equation implements the crucial disequilibrium assumption. Due to sticky interest rates, quantities have to adjust and the observed outcome is set equal to the shorter market side. Which market side we truly observe is unknown. Given the parameter estimates and data, we can only assign a probability to each observation of belonging to the demand or the supply side and set the market side that is likely to be smaller equal to the observed market volume. The other market side is unobserved and treated as a latent variable.

3.4.1 Estimation

Historically, disequilibrium models have been estimated by means of classical methods, i.e., maximum likelihood estimation. In this context, Maddala and Nelson (1974) made a significant contribution by deriving general likelihood functions for this class of models. However, in this scenario, maximum likelihood estimation runs quickly into problems. The complexity of disequilibrium models leads to non-monotonic and non-smooth likelihood functions where numerical optimization techniques prove to be indispensable. Nevertheless, it is likely that optimization algorithms get stuck in local optima and do not converge to the global optimum.

An alternative approach, which avoids numerical optimization, is to resort to bayesian estimation techniques. In particular, Bauwens and Lubrano (2007) paved the way by proposing an elegant way to estimate dynamic disequilibrium models with bayesian methods. They use a dynamic version of the disequilibrium model, apply the data augmentation principle by Tanner and Wong (1987) for treating the unobserved data problem and use Gibbs sampling to obtain posterior distributions of the model parameters. Tanner and Wong propose to apply a Gibbs sampler to draw the latent variable and model parameters iteratively. More specifically, the latent variable is sampled conditionally on the model parameters and the observed variables, and then the model paramaters are in turn updated conditionally on the simulated latent variable and the observed variables. This poses no problem since the conditional distributions are known (see Section 3.4.2). We follow closely their estimation procedure and apply it to our static disequilibrium model.

The estimation procedure can be separated into two stages. First, we determine for each point in time which regime, demand or supply, conditional on the data and parameter estimates, is observed. Second, given the sample separation, we draw parameters from conditional probabilities and by averaging them we obtain their posterior means and distributions. These steps are iterated until parameter estimates have converged.

3.4.2 Bayesian inference

We apply a normal linear regression model and estimate it with bayesian methods to derive posterior estimates. We use a natural conjugate prior that has the same distributional form as the likelihood.[11] We elicit priors of the following form:

$$\pi(h_i) \sim \mathcal{G}(\underline{s_i}^{-2}, \underline{\nu_i}) \quad \text{and} \quad \pi(\beta_i|h_i) \sim \mathcal{N}(\underline{\beta_i}, h_i^{-1}\underline{V_i}).$$

h_i is the error precision, i.e., $h_i = \sigma_i^{-2}$. Their joint prior distribution is called a normal-gamma distribution:

$$\pi(\beta_i, h_i) = \pi(\beta_i|h_i) \times \pi(h_i) \sim \mathcal{NG}(\beta_i, h_i|\underline{\nu_i}, \underline{s_i}^{-2}, \underline{\beta_i}, \underline{V_i})$$

for $i = 1$ (demand) and 2 (supply). $\mathcal{G}(\cdot,\cdot)$ represents a gamma distribution, $\mathcal{N}(\cdot,\cdot)$ a normal distribution and $\mathcal{NG}(\cdot,\cdot,\cdot,\cdot)$ a normal-gamma distribution. In general, the hyperparameters are defined as follows:

$$\begin{aligned}
\underline{\nu_i} &= T - k_i, \\
\underline{\beta_i} &= \beta_{i,OLS}, \\
\underline{s_i}^2 &= \frac{(y_i - x_i\underline{\beta_i})'(y_i - x_i\underline{\beta_i})}{\underline{\nu_i}}, \\
\underline{V_i} &= diag(Var(\beta_{i,OLS})),
\end{aligned}$$

where $\underline{\nu_i}$ is the degree of freedom with T equal to the number of observations and k_i equal to the number of co-variates. $\underline{\beta_i}$ is the OLS estimator, and $\underline{s_i}^2$ is defined as the error variance. Finally, $\underline{V_i}$ represents the covariance matrix of the OLS estimator where all off-diagonal entries are zero. The prior hyperparameters allow the econometrician to introduce prior information that he has about the economic problem. We take a neutral standpoint and do not impose any external information. This means that we choose non-informative priors, which amounts to setting $\underline{\nu_i}$ and $\underline{V_i}^{-1}$ equal to zero. Since we use a natural conjugate prior, it follows that the posterior belongs to the same family of distributions, i.e.:

$$p(\beta_i, h_i|y_i) \sim \mathcal{NG}(\bar{\nu}_i, \bar{s}_i^{-2}, \bar{\beta}_i, \bar{V}_i),$$

[11] Notation draws on the book by Koop (2003). Variables with underscores are normally prior values and variables with bars posterior values.

Note that posterior quantities depend on sampled values, y_i, of the dependent variable. The posterior parameters read as follows:

$$\begin{aligned}
\bar{\nu}_i &= \underline{\nu}_i + T, \\
\bar{V}_i &= (\underline{V_i}^{-1} + x_i' x_i)^{-1}, \\
\bar{\beta}_i &= \bar{V}_i(\underline{V_i}^{-1}\underline{\beta}_i + x_i' x_i \beta_{i,OLS}), \\
\bar{\nu}_i \bar{s}_i^2 &= \underline{\nu}_i \underline{s}_i^2 + \nu_i s_i^2 + (\beta_{i,OLS} - \underline{\beta}_i)'[\underline{V_i} + (x_i' x_i)^{-1}]^{-1}(\beta_{i,OLS} - \underline{\beta}_i).
\end{aligned}$$

Finally, the marginal posterior for the error precision and the conditional posterior for the parameter vector of explanatory variables are:

$$p(h_i|y_i) \sim G(\bar{s}_i^{-2}, \bar{\nu}_i) \quad \text{and} \quad p(\beta_i|h_i, y_i) \sim N(\bar{\beta}_i, \bar{V}_i).$$

Now, the following two equations represent the demand and supply equation for credit:

$$d_t^{(j)} = x_{1t}' \beta_1^{(j)} + u_{1t}^{(j)} \text{ and} \tag{3.8a}$$

$$s_t^{(j)} = x_{2t}' \beta_2^{(j)} + u_{2t}^{(j)}, \tag{3.8b}$$

where the superscript j indicates the j-th draw in our bayesian estimation cycle. The first iteration, $j = 1$, is initialized with OLS estimates, assuming that the market is in equilibrium, i.e., $q_t = d_t = s_t$.[12] These values are used in turn to determine which regime is operative. We now draw a value $U_t^{(j)}$ for each observation from a uniform distribution. Given the estimates, we can calculate the probability, $\lambda_t^{(j)}$, of the notional demand being shorter than notional supply:

$$\lambda_t^{(j)} := \mathbb{P}(d_t^{(j)} < s_t^{(j)}) = \Phi\left(\frac{x_{2t}'\beta_2^{(j)} - x_{1t}'\beta_1^{(j)}}{\sqrt{\sigma_2^{2(j)} + \sigma_1^{2(j)}}}\right). \tag{3.9}$$

Φ designates the standard normal distribution function and $\sigma_1^{2(j)}$ and $\sigma_2^{2(j)}$ are the variances of the notional demand and supply equations, respectively. We now assign the observed credit variable in the following way:

$$\text{If } U_t^{(j)} < \lambda_t^{(j)} \text{ then } y_{1t}^{(j+1)} := q_t \text{ and draw } y_{2t}^{(j+1)} \sim \mathcal{TN}_{d_t^{(j)} < s_t^{(j)}}(x_{2t}'\beta_2^{(j)}, \sigma_2^{2(j)}), \tag{3.10}$$

$$\text{If } U_t^{(j)} > \lambda_t^{(j)} \text{ then } y_{2t}^{(j+1)} := q_t \text{ and draw } y_{1t}^{(j+1)} \sim \mathcal{TN}_{s_t^{(j)} < d_t^{(j)}}(x_{1t}'\beta_1^{(j)}, \sigma_1^{2(j)}), \tag{3.11}$$

where $y_1^{(j)}$ and $y_2^{(j)}$ represent vectors of demand and supply, respectively, that are stacked with observed or sampled values of the dependent variable. $\mathcal{TN}$ denotes a truncated normal

[12]Taking OLS estimates to initialize the procedure is unproblematic because the influence of starting values on the results diminishes along the iteration process.

probability distribution. At this stage, the market side which is more likely to be shorter is set equal to the observed credit variable and the other market side, which is likely to be larger and not observable, is sampled from a truncated normal probability distribution. The estimation procedure can be summarized by the following pseudo-code:

1. $(\beta_1^{(j)}, \beta_2^{(j)}, \sigma_1^{2(j)}, \sigma_2^{2(j)}) = (\beta_1^{(j-1)}, \beta_2^{(j-1)}, \sigma_1^{2(j-1)}, \sigma_2^{2(j-1)})$, where $j = 1$ corresponds to OLS estimates.

2. For $t = 1, ..., T$:

   Calculate $\lambda_t^{(j)}$ as in (3.9) and draw $U_t^{(j)}$ from a uniform distribution.

   If $U_t^{(j)} < \lambda_t^{(j)}$, set $y_{dt}^{(j+1)}$ equal to q_t and sample $y_{st}^{(j+1)}$ as in (3.10).

   If $U_t^{(j)} > \lambda_t^{(j)}$, set $y_{st}^{(j+1)}$ equal to q_t and sample $y_{dt}^{(j+1)}$ as in (3.11).

3. Draw $(\beta_1^{(j+1)}, \beta_2^{(j+1)}, \sigma_1^{2(j+1)}, \sigma_2^{2(j+1)})$ from conditional posterior distributions.

3.4.3 Model specification

In our analysis, we focus on the German credit market for firms. We use monthly data from January 1999 up to December 2014. We draw our data mainly from the Deutsche Bundesbank. Our explained variable represents an aggregate credit variable to enterprises and self-employed working people comprising different maturities.[13] The selection of the variables we include in our model is largely based on the theoretic model in section 3.3. We map every variable from our model to an empirical counterpart, except for equity costs due to data constraints. In the credit demand equation we include industrial production (Y), the lending rate (i_B) and the corporate bond rate (i_{NB2}). On the supply side equation we introduce, again, industrial production and the lending rate and, in addition to that, a spread between the bank lending rate and the refinancing rate (Spread 1, $i_B - i_R$), a spread between the bank bond rate and the refinancing rate (Spread 2, $i_{NB1} - i_R$) and the percentage of non-performing loans (npl) in Germany.[14] Accordingly, our baseline reads as follows:

$$\begin{aligned}
\log(Cr_t^D) &= c_1 + \beta_{12}\log(\mathrm{Y}_{t-12})\beta_{13}i_{B,t} + \beta_{13}i_{NB2,t} + u_{2,t}, \\
\log(Cr_t^S) &= c_2 + \beta_{22}\log(\mathrm{Y}_{t-12}) + \beta_{23}i_{B,t} + \beta_{24}(i_B - i_R)_t + \beta_{25}[\eta_B(i_{NB1} - i_R)]_t ... \\
&\quad + \beta_{26}\mathrm{npl}_t + u_{1,t}.
\end{aligned}$$

[13]for more details see Appendix Table 3.6.

[14]In contrast to the theoretic model, we apply the actual bond rates for banks and non-financial corporations.

We estimate the model in levels. All variables, except interest rates and spreads, are expressed in logs. We take 100.000 bayesian draws and discard the first 25.000 draws as burn-in. To ensure convergence of the parameters, we apply Geweke-statistics (Geweke et al., 1991) and inspect the convergence of the model parameters visually.

3.5 Results

The estimation results of the German market for firm credit are illustrated in Table 3.2. Since disequilibrium models are possibly prone to instability, we test for their robustness by applying different estimation methods. The first column depicts bayesian estimates, the second column maximum likelihood estimates and the third column OLS estimates. For inference, we adjust for autocorrelated residuals. Closer inspection reveals that the estimates are of similar magnitude, quantitatively and qualitatively, independent from the estimation method.

Starting with the credit demand equation, we find significant effects at the 5 percent level for industrial production, the lending rate and the corporate bond rate. Industrial production and the corporate bond rate affect credit demand positively. A one percent increase in industrial production leads to a 0.16 percent increase in credit demanded, and a rise in the corporate bond rate by one percentage point increases credit demand by 0.03 percent. The lending rate, however, factors in negatively with a coefficient of around 0.02. Qualitatively, the estimates are consistent with theory. Increases in industrial production need credit for financing labor and capital services that flow into the production of goods. A higher lending rate, which represents the cost of credit, has the tendency to reduce credit demand. Finally, higher corporate bond rates imply that funding via the bond market becomes more expensive for firms. Consequently, firms are more willing to finance their expenses with bank credit.

Turning to the credit supply equation, we do not detect a significant effect of industrial production on credit supply. Apart from that, the remaining estimates prove to be significant at the 1 percent level. We find a positive estimate for the lending rate, which represents higher bank revenues for a given volume of credit, and for spread 1 (the spread between lending rate and refinancing rate), which expresses a profit margin that incentivizes banks to supply more credit. Compared to the lending rate estimate it is even more important quantitatively. The only variable that factors in negatively is spread 2 (the spread between

Table 3.2: Baseline estimation results of the German market for firm credit

	Model 1 Bayesian	Model 2 Maximum Likelihood	Model 3 OLS
Credit Demand			
Constant, c_1	5.945***	5.936***	6.254***
	(0.347)	(0.151)	(0.302)
Industrial production[1], Y	0.157**	0.159***	0.087
	(0.073)	(0.031)	(0.063)
Lending rate, i_B	-0.021**	-0.006*	-0.024***
	(0.01)	(0.004)	(0.009)
Corporate bond rate, i_{NB2}	0.027**	0.01***	0.028***
	(0.011)	(0.003)	(0.007)
Credit Supply			
Constant, c_2	5.839***	5.64***	5.486***
	(0.466)	(0.664)	(0.592)
Industrial production[1], Y	0.13	0.146	0.232*
	(0.095)	(0.138)	(0.121)
Lending rate, i_B	0.047***	0.078***	0.019**
	(0.016)	(0.013)	(0.008)
Spread 1, $(i_B - i_R)$	0.097***	0.143***	0.042***
	(0.023)	(0.024)	(0.012)
Spread 2, $\eta_B(i_{NB1} - i_R)$	-0.039	-0.03	-0.017
	(0.05)	(0.047)	(0.034)
Non-performing loans, npl	-0.057***	-0.099***	-0.021
	(0.018)	(0.021)	(0.015)

Dependent variable: Credit to non-financial firms and self-employed persons.

[1] Industrial production enters with its 12^{th} lag.

Standard errors in parenthesis. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Two-tailed test.

the bank bond rate and the refinancing rate). Spread 2 can be given the interpretation of a cost, representing maturity transformation. Therefore, it is reasonable to find a negative coefficient. In summary, the regression results indicate that prices play a significant role in the determination of credit. On the supply side, we find a significant and positive role for price variables on credit that influence the banks' revenue. In contrast to other studies, we do not include quantity variables like deposits into the credit supply equation because this would be in conflict with our earlier discussion of the banks' ability to create credit by pure will. It would be problematic to explain credit causally with deposits when the act of extending credit creates simultaneously deposits. On the demand side, we introduce subsitutability for firms between bank and non-bank financing where the possibility of arbitrage between the two forms of finance seems to play a significant role. Altogether, our findings support our price-theoretic modeling approach of bank credit.

Figure 3.3: Observed bank credit to firms and self-employed people and notional credit demand and supply

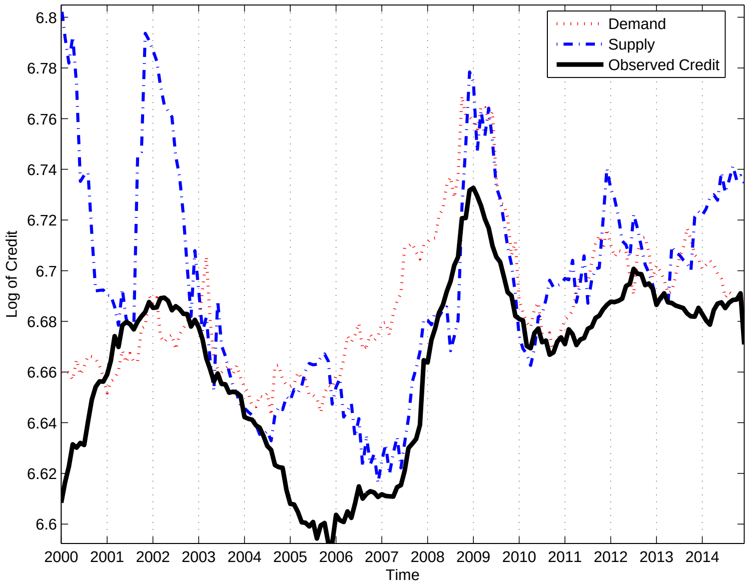
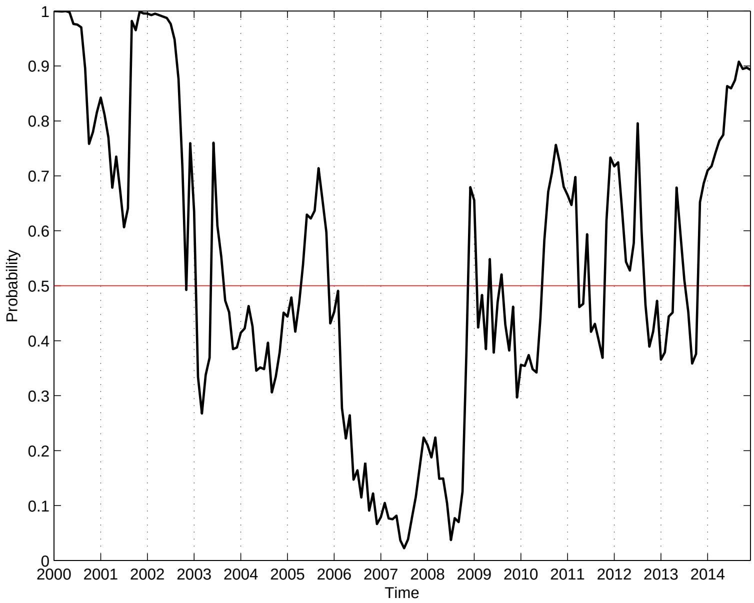


Figure 3.3 illustrates observed bank credit to firms and self-employed people (black line), notional credit demand (dashed red line) and notional credit supply (dashed-dotted blue line). This representation indicates which market side was likely to be the restricting market side for every point in our sample. In the period before the financial crisis in 2007, we identify two sub-periods with excess supply. The first one is around 1999 to 2003 which is in line with the economic malaise in Germany at that time. During this period, Germany was characterized by low economic growth, low inflation and high unemployment rates. On account of the large weight of Germany in the Eurozone, its low inflation rates forced the ECB to keep interest rates at a relatively low level in order to meet its mandate of price stability for the Eurozone. As a consequence, the loose monetary policy was one factor for the boom in southern European countries, especially in Greece and Spain, where low nominal rates and high inflation rates translated into low real rates, provoking economic expansions. In Germany, the low growth rates eventually led the German government to undertake far-reaching reform measures (Agenda 2010). The second sub-period, in 2005, was described by a more stable environment with constant inflation and moderate growth. Due to the announcement of the Basel II-regulations in 2004, which were finally adopted in 2007, firms were obliged to reach better balance sheet figures in order to fulfill the new regulations. In addition to and as a consequence of the Basel II-regulations, firms increased their share of internal financing that made up almost the entire volume of finance during

the years 2004 and 2005 (Deutsche Bundesbank, 2012). Both factors contributed to a credit supply overhang. Following this excess supply period, the most distinct period extends from 2006 until 2010. Until 2008 we observe a sharp increase in bank credit. With the outbreak of the financial crisis, the credit expansion came to a halt and we observed a decline in credit until 2010. During the increase and decrease, our model suggests an excess demand regime. Hence, the uptrend in credit before 2008 could have been stronger if the banks had been willing to lend more. In the aftermath of the financial crisis, no clear demand or supply regime can be identified. The safety programs for banks from the ECB and the German Bund (Soffin) as well as the stimulus package of the German Bund contributed to a fast recovery of the credit market after the crisis. In 2014, the EBA-stress testing constrained the banks' willingness to grant credit due to the high uncertainty surrounding the test results.

Figure 3.4: Probability of a demand regime (demand is restricting force)



After the publication of the positive results for German banks in November 2014, notional credit supply started to exceed notional credit demand. Since 2014, the demand for bank credit starts to decrease. This could hint at the influence of geopolitical risks and reflect the slow growth environment in the Eurozone. Figure 3.4 provides an alternative presentation of our results. The graph shows the estimated probability of observing a demand regime for every observation in the sample. The sequence of probabilities represents a probabilistic counterpart to Figure 3.3. Plotting notional demand and supply, as in Figure 3.3, illustrates which market side might be the constraining force. Computing the probability of a demand or supply regime, complements our analysis in terms of providing the likelihood of a specific regime. The regime probabilities support our previous observations. At the beginning of the millennium up to 2003, we observe an elevated likelihood of a demand regime greater than 0.7. And then again in 2005. In between, we have changing patterns with equally likely regimes. Following this, we identify the most characteristic period of our sample. From 2006 to 2010, our model suggests a supply restricting regime with a probability of approximately 0.9. This is consistent with an acceleration of the German economy before the crisis. After 2010, we have, again, alternating regime probabilities marked by occasional spikes.

An important caveat of this type of analysis is that it is not possible to structurally pin down the exact reasons for an eventual shortage in demand or supply. The model design only allows to analyze whether a demand or supply schedule is more likely. Nevertheless, we checked the plausibility of the model by relating the results to developments that took place at the same time.

3.6 Conclusion

We present a model of an aggregate credit market. Banks operate as profit-maximizing firms and serve credit demand by non-banks. The model integrates the central bank, banks, and non-banks into the determination of credit supply. The central bank sets the refinancing rate for base money which influences the supply of bank credit. Bank supply and firm demand for bank loans determine the equilibrium market rate and credit volume. Banks then demand a fraction of their credit business, determined by the bank credit multiplier, in form of base money on the market for central bank credit. In our model, credit business precedes the banks' refinancing operations, which is a better description of how banks operate in reality. Besides base money from the central bank and deposits as a source of refinancing, the banks in our model also have the opportunity to back their credit business via equity and bond markets. At last, we put our model to a test and estimate a market for German firm credit and show that the determinants of credit supply and demand, that have been selected on account of our theoretic model, play a significant role. In addition to that, our empirical framework of a disequilibrium model allows to identify periods of credit supply or credit demand overhang between 1999 and the end of 2014.

3.7 Appendix to chapter 3

Table 3.3: Central Bank's balance sheet

Assets	Liabilites
Credit from Central Bank	Reserves R
to Banks $Cr_{CB/B}$	Cash C

Table 3.4: Bank's balance sheet

Assets	Liabilites
Credit from Banks	Equity E
to Non-banks $Cr_{B/NB}$	Bonds B
Reserves R	Deposits D
	Credit from Central Bank to
	Banks $Cr_{CB/B}$

Table 3.5: Non-bank's balance sheet

Assets	Liabilites
Deposits D	Credit from Banks to
	Non-banks $Cr_{B/NB}$
Cash C	
Bonds B	
Equity E	

Table 3.6: Description of variables

Variable	Transformation	Source
Credit to non-financial firms	SA, log-level	Bundesbank
Industrial production	SA, log-level	Destatis
Bank lending rate	Level, %	Bundesbank
Corporate bond rate	Level, %	Bundesbank
Bank bond rate	Level, %	Bundesbank
Refinancing rate	Level, %	Bundesbank
Non-performing loans	Level, %, interpolated (cubic)	Worldbank

Figure 3.5: Credit to non-financial corporations and self-employed people (in logs)

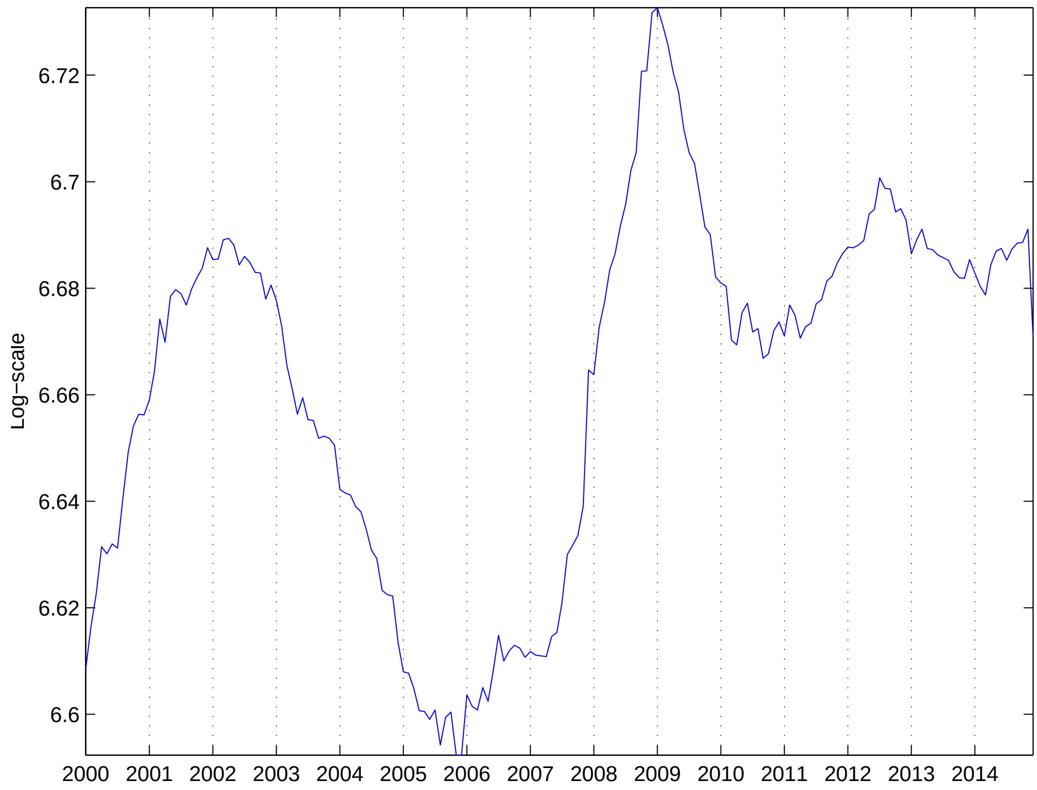


Figure 3.6: Supply side variables

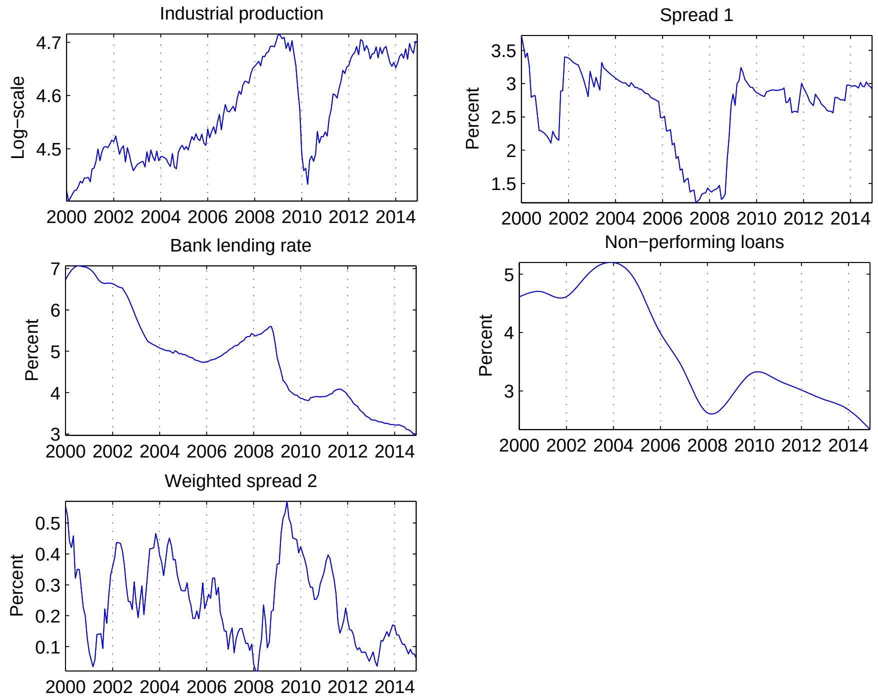


Figure 3.7: Demand side variables

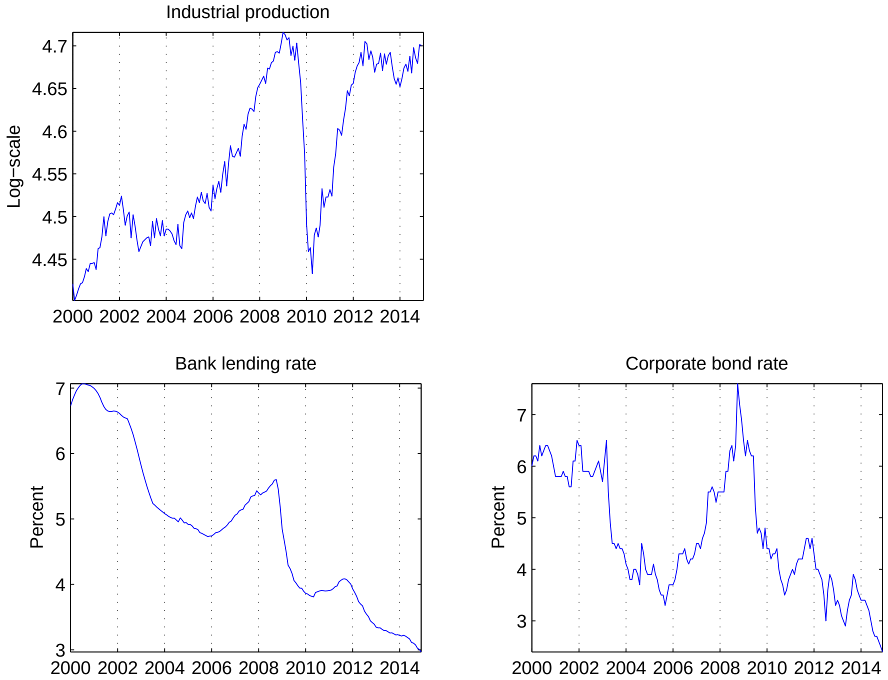


Table 3.7: Unit root tests for model variables

Variable	Test	P-val.		Test-stat.	Crit.-val.: 5%	Decision
log(loans)	ADF (w Trend)	0,3162				not stat.
	ADF (wo Trend)	0,1515				not stat.
	Phillips-Perron (w Trend)	0,0042				stat.
	Phillips-Perron (wo Trend)	0,0002				stat.
	KPSS (w Trend)			0,0951	0,146	not stat.
	KPSS (wo Trend)			0,7230	0,463	stat.
log(ip)	ADF (w Trend)	0,0654				not stat.
	ADF (wo Trend)	0,2789				not stat.
	Phillips-Perron (w Trend)	0,2297				not stat.
	Phillips-Perron (wo Trend)	0,4480				not stat.
	KPSS (w Trend)			0,0636	0,146	not stat.
	KPSS (wo Trend)			1,3846	0,463	stat.
loan rate	ADF (w Trend)	0,0330				stat.
	ADF (wo Trend)	0,9259				not stat.
	Phillips-Perron (w Trend)	0,1046				not stat.
	Phillips-Perron (wo Trend)	0,9435				not stat.
	KPSS (w Trend)			0,0673	0,146	not stat.
	KPSS (wo Trend)			1,5672	0,463	stat.
corporate bond rate	ADF (w Trend)	0,4380				not stat.
	ADF (wo Trend)	0,7352				not stat.
	Phillips-Perron (w Trend)	0,3706				not stat.
	Phillips-Perron (wo Trend)	0,6771				not stat.
	KPSS (w Trend)			0,1331	0,146	not stat.
	KPSS (wo Trend)			0,8615	0,463	stat.
spread 1	ADF (w Trend)	0,6843				not stat.
	ADF (wo Trend)	0,3799				not stat.
	Phillips-Perron (w Trend)	0,3465				not stat.
	Phillips-Perron (wo Trend)	0,1364				not stat.
	KPSS (w Trend)			0,1840	0,146	stat.
	KPSS (wo Trend)			0,2193	0,463	not stat.
Spread 2× bond ratio	ADF (w Trend)	0,1885				not stat.
	ADF (wo Trend)	0,2114				not stat.
	Phillips-Perron (w Trend)	0,0435				stat.
	Phillips-Perron (wo Trend)	0,0513				not stat.
	KPSS (w Trend)			0,0789	0,146	not stat.
	KPSS (wo Trend)			0,537	0,463	stat.
npl	ADF (w Trend)	0,0323				stat.
	ADF (wo Trend)	0,7272				not stat.
	Phillips-Perron (w Trend)	0,6824				not stat.
	Phillips-Perron (wo Trend)	0,9335				not stat.
	KPSS (w Trend)			0,1480	0,146	stat.
	KPSS (wo Trend)			1,3741	0,463	stat.

ADF = Augmented Dickey Fuller test.
KPSS = Kwiatkowski-Phillips-Schmidt-Shin test.
w.= with; wo.=without.

Chapter 4

The bond market: terra incognita in the monetary analysis

4.1 Introduction

In the last few years the old debate on the role of banks in the financial system (Werner, 2014) has gained new momentum. Regarding the fundamental question of whether banks are only intermediaries between savers and investors or are originators of loans and money economists as well, central banks tend to favor the latter view. Bofinger and Ries (2017) have shown that the controversy surrounding such a core institution of the economic system is due to the coexistence of two mutually exclusive paradigms:

- In the 'real analysis', upon which the whole neoclassical framework is based, 'funds' consist of a standard commodity which can be used as both a consumption and an investment good. This commodity is made available by savers who are willing to abandon consumption. Doing so makes it possible to transfer the commodity via the banking system or the bond market to investors. In this framework, banks are unable to produce the standard commodity, and thus serve solely as a conduit for the transmission of this commodity.

- In the 'monetary analysis', upon which the Keynesian paradigm is based, 'funds' consist of money balances that are held by banks. Thus banks play a central role, as they are the only institution which can create the funds which are required for investment projects.

There is now a growing awareness that banks can no longer be regarded as pure intermediaries that more or less passively channel the funds that are generated from savers to investors. In the post Keynesnian literature the microeconomic fundamentals of this process have been worked out in detail (Palley, 2013). This literature shows, above all, that although banks are able to create money 'ex nihilo', this does not imply that the money supply can no longer be controlled by the central bank. But this control is not exercised via quantitative targeting of reserves, it is achieved by adjustment of the central bank's policy rates. This price-theoretic approach corresponds with the actual practice of conventional monetary policy carried out by all central banks. While the role and the functioning of banks in the paradigm of the monetary analysis has received increasing attention, the implications of the monetary paradigm for the role and the theory of bond markets have so far been totally neglected. In light of the substantial and growing importance of bond markets, it is even more surprising that there exist almost no comprehensive descriptions of its functions and its implications for macroeconomic processes. This theoretical deficit is especially problematic, as the unconventional measures of monetary policy (quantitative easing) directly affect the bond market. With a standard bank model these effects cannot be adequately discussed. In the following, I will show the fundamental differences in the functioning of bond markets in the real and in the monetary analyses. I will then present the main determinants of the supply of funds and the demand for funds in the monetary model of the bond market. This provides the basis for development of a comprehensive model of the bank credit market and the bond market. The model depicts the interactions between the two markets, and it also enables demonstration of the direct and indirect effects of quantitative easing on the bond and on the bank credit markets.

4.2 The bond market in the real and in the monetary analyses

A key insight of the monetary analysis is the difference between banks, which create new money/deposits, and the bond market, which redistributes or intermediates existing money balances held by banks. At first glance, this role of the bond market does not appear to be incompatible with the view of the real analysis that bond markets intermediate between savers and investors.

The differences are, however, fundamental, and this is primarily due to the fact that in the real analysis the **funds** that are supplied are made up of the standard commodity. In the monetary analysis the funds are money balances, i.e. deposits held by banks. As a consequence, the **suppliers of funds** in the real analysis are savers (private households) that decide to abandon consumption, which frees up the standard commodity as a means of financing for the financial system. In the monetary analysis, the suppliers of funds are wealth-holders in possession of liquid money balances that are willing to exchange them for bonds. Thus, they do not decide to abandon consumption, rather they decide to abandon liquidity. It is not logically imperative that these suppliers be savers, i.e. that they simultaneously increase their net wealth. Thus, the process of financing in the bond market is completely disconnected from the process of saving during the same period.

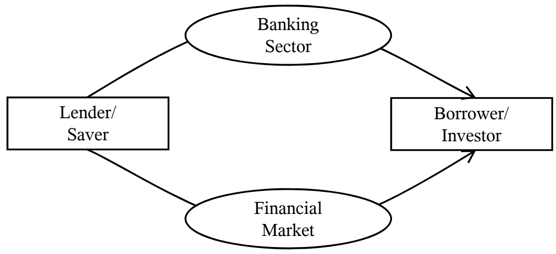
Differences between the real and the monetary analyses are also related to the **demand for funds**. The real analysis assumes that the demand for funds arises due to investment in new assets. In the monetary analysis, the demand for funds also arises due to the purchase of existing real assets (real estate, firms), the financing of government deficits, and the refinancing of banks which reduce the maturity transformation of the balance sheet by issuing longer-term bonds.

As a result, in the monetary analysis the supply of funds is disconnected from saving, and the demand for funds is only partially related to new investment. This has far-reaching implications for the **interest rate in the bond market**. In the real analysis the interest rate is a real interest rate, expressed in units of the standard commodity tomorrow for one unit of the standard commodity today. It is determined only by real factors, the time preference of savers and the productivity of investment. In the monetary analysis the interest rate is a purely monetary phenomenon. In fact, there exist two money interest rates: the interest rate for bonds and the interest rate for money holdings (deposits).

A further difference between the 'real analysis' and the 'monetary analysis' concerns the **credit potential** of the bond market. In the real analysis the standard commodity can be used only once for a credit process. As it is used not only as a means of financing but also as a means of investment, it is absorbed by the investment process. In the monetary analysis the means of financing (money) and the means of investment (labor, machines) are different. Thus, a given amount of money can be used repeatedly, as the investor uses the amount of money that they raised in the bond market almost instantaneously for the purchase of real assets or for hiring workers. Thus, the money raised in the bond market is again available for further lending.

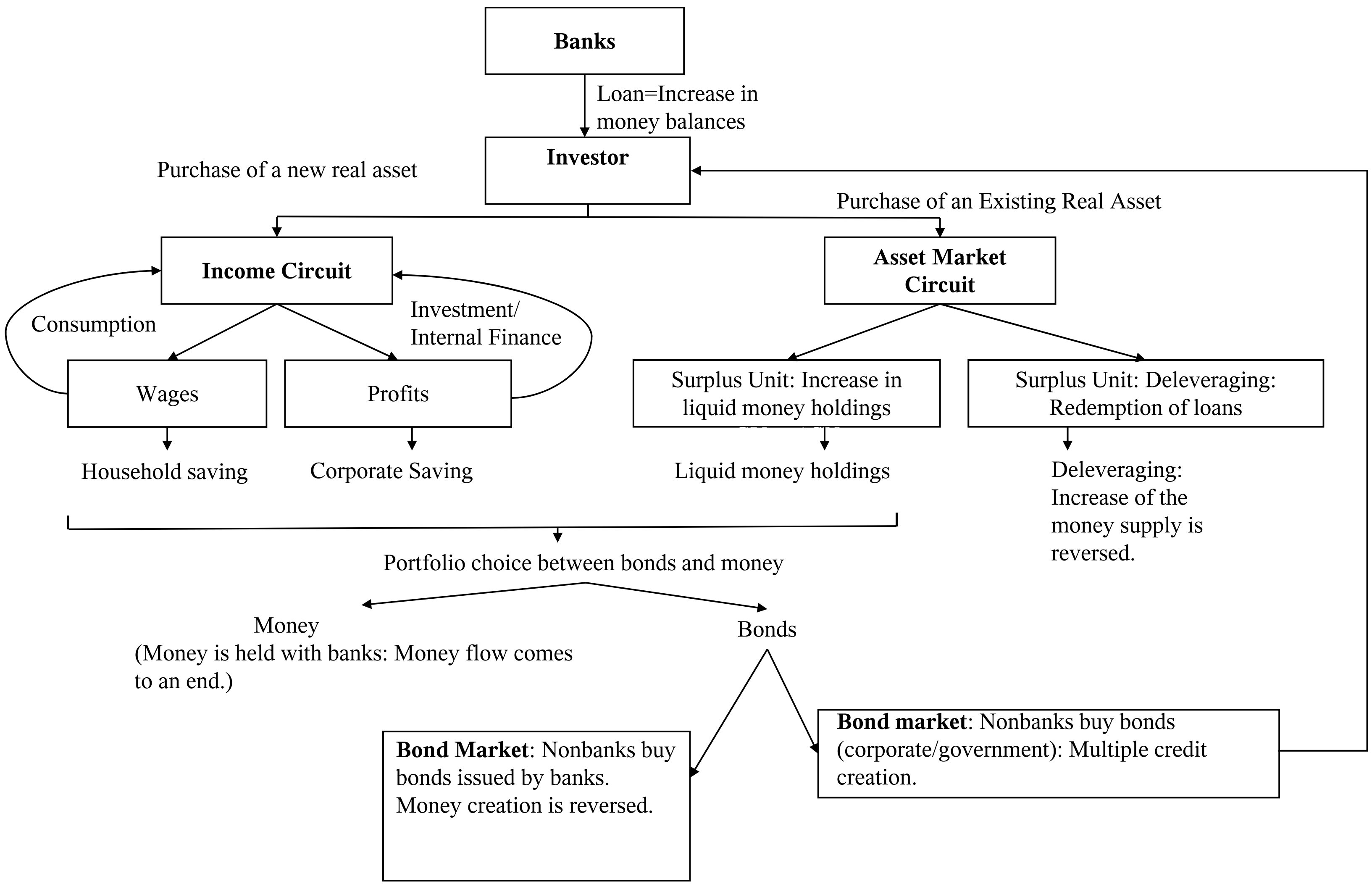
This aspect is also underlined by a comparison of the flow of funds in the real and the monetary analyses. In the real analysis the flow of funds is a one-way stream: funds flow from savers to investors (see Figure 4.1).

Figure 4.1: Flow of funds in the real analysis



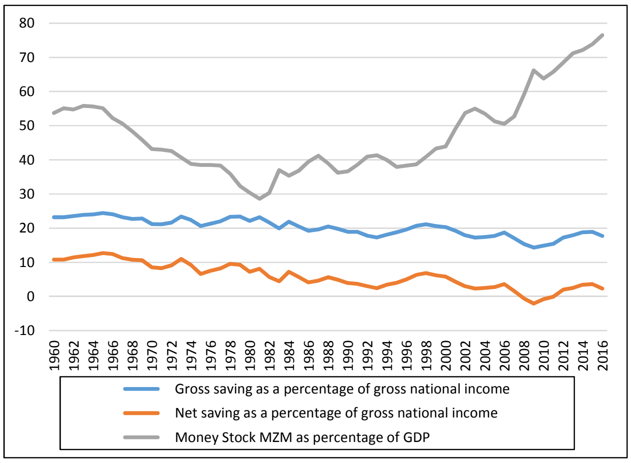
In the monetary analysis the source of funds is banks, which make them available for investors. But the funds do not stop there, as they are almost immediately used for the purchase of new or existing assets (see Figure 4.2). Through the purchase of new assets, the funds flow into the income circuit, where income is generated and distributed to wages and corporate profits. Households and entrepreneurs split their income into consumption and saving, where saving is freed up for the portfolio choices of either holding money or buying bonds. If the investor buys an existing asset, the funds flow into the asset market circuit. The seller of the asset is called the surplus unit, and they have the option to redeem outstanding loans (deleveraging), which destroys money, or to increase their money holdings with their incoming funds. In addition to household and corporate saving, the money holdings of the surplus unit contribute to the amount of money available for portfolio decisions. At this point, money is held as deposits with banks and the money flow comes to an end. When the decision is made to purchase bank bonds, the result is similar to that of deleveraging, because in this case money is destroyed as well. However, deciding to purchase corporate or sovereign bonds in the bond market leads to a backward flow to an investor, at which point the money flow begins again.

Figure 4.2: Flow of funds in the monetary analysis



The two different views have far-reaching implications for the analysis of the bond market. In the real economy paradigm, the flow of savings determines the supply of funds. In the monetary economy paradigm, the stock of liquid money holdings provides the supply of funds which can be used more than once. A look at the relationship of annual saving to GDP and of the money stock MZM (including assets of zero maturity) to GDP reveals completely different trends (see Figure 4.3). While saving has declined since the 1980s, the amount of liquid money holdings relative to GDP has increased. Furthermore, with regard to its size the money stock is a multiple of annual saving, particularly if it is expressed on a net basis.

Figure 4.3: Saving and money stock as percentage of GDP in the USA



Source: Federal Reserve Bank of St. Louis and own calculations.

Table 4.1: Overview Real vs. Monetary Analysis

	Real Analysis	Monetary Analysis
Funds	Standard commodity	Money balances
Supply of funds	Savers abandoning consumption.	Money holders abandoning liquidity.
Demand for funds	Investors for new investments.	Investors for new investments and for purchase of existing real assets.
Interest rate	One interest rate: Real rate determined by time preferences and productivity.	Two interest rates: Bond rate determined by liquidity preference and by expected profitability of investments. Money interest rate determined by the central bank.
Credit potential	The standard commodity can be used only once as means of financing.	Money can be used several times as a means of financing.

4.3 The supply and the demand in the bond market in the monetary model: Stylized facts

To gain an understanding of the bond market, it is important to look at the determinants of both the supply of and the demand for funds. Since money is exchanged temporarily for bonds in this market, the supply of funds is identical to the demand for bonds, and the demand for funds is thus also identical to the supply of bonds. Thus, the bond market can be viewed either as a market for money, i.e. liquid funds or, as a market for bonds.

4.3.1 The supply of funds (= demand for bonds) in the bond market

While savers play the decisive role in the real model, in the monetary model it is wealth holders who occupy a central position. They must decide which part of their portfolio they will hold as money. To simplify the portfolio choice, I assume that the only alternative to holding money is the holding of bonds. A starting point for such a model was provided by John Maynard Keynes with his theory of liquidity preference (LPT). Unfortunately this theory has since been almost entirely forgotten, or even reversed into the opposite (Chick and Tily, 2014). Keynes describes the main insight of the LPT as follows:

> „The mere definition of the rate of interest tells in so many words that the rate of interest is the reward for parting with liquidity for a specified period.“(Keynes, [1930] 1971b, p.167)

In this theory, Keynes ([1930] 1971b, p.170) differentiates between three different types of liquidity preference:

1. „the transactions-motive, i.e. the need of cash for the current transaction of personal and business exchanges;
2. the precautionary-motive, i.e. the desire for security as to the future cash equivalent of a certain proportion of total resources; and
3. the speculative-motive, i.e. the object of securing profit from knowing better what the market of the future will bring forth.“

As far as the transactions and the precautionary motive are concerned, Keynes assumes that this demand „is not very sensitive to changes in the rate of interest as such“(Keynes, [1930] 1971b, p.171). Thus for the speculative motive, the amount of money available is the total amount of money minus the money that is absorbed by the first and the second motives. A main issue of this presentation is the term 'speculative-motive'. What Keynes had in mind is the use of money not as a means of payment, but rather as a store of value. And in this function the holding of money represents just the opposite of 'speculative'. It reflects the desire of wealth holders to invest a part of their wealth in a form which is absolutely safe. Thus, it would be more appropriate to speak of a 'portfolio motive'.[1] This demand for money raises the following question:

> „Why should anyone outside a lunatic asylum wish to use money as a store of wealth?“(Keynes, [1930] 1971b, p.216)

Standard textbook explanation

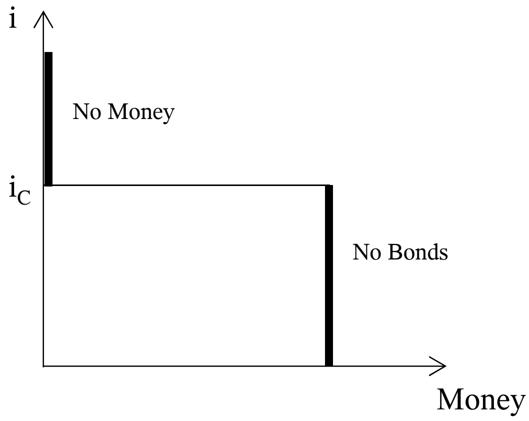
The standard textbook explanation of the speculative demand for money assumes that a wealth holder has two options:

- holding non-interest bearing money, or
- holding perpetual bonds ('consols'), i.e. bonds with no maturity date. The issuer of the bond has to pay coupons on this bond forever.

For a given short-term investment period, the wealth holder has to decide whether to hold a certain amount of their portfolio as money or bonds. They will decide to hold it as money if they expect, for the holding period, a decline in the price of the bond that exceeds the interest payment for that period. In order to make this decision, they must forecast the development of the bond interest rate over the holding period. Since bond prices decline if interest rates increase, lower bond rates lead to a reduction in the preference for holding bonds. If interest rates fall, the demand for money as a store of value increases. One can assume the existence of a 'critical' long-term interest rate for a given investor, who expects rates below this threshold to increase in the long term (see Figure 4.4). Thus, if the current long-term rate is below the critical rate i_C, they will decide to hold money only. If the current interest rate is higher than the critical rate, they will hold it solely as bonds.

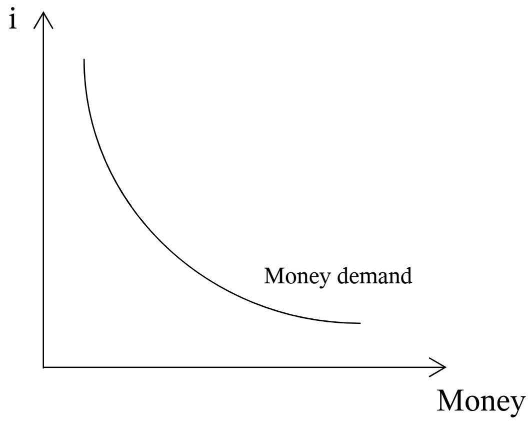
[1] Keynes ([1930] 1971b) often speaks of 'hoarding'.

Figure 4.4: Individual wealth holder's speculative demand for money



As different investors calculate diverging estimates of the critical interest rate, a downward sloping speculative demand curve for money can be derived for the economy as a whole (see Figure 4.5).

Figure 4.5: Speculative demand for money



In this standard textbook framework, the uncertainty of the investor concerns the development of the long-term interest rate. The short-term interest is known, as it is always equal to zero. This implies that the holding period for which the portfolio decision has to be made is shorter than the maturity of the bond.

Alternative explanation based on the expectations theory of interest rates

For a more realistic explanation of the portfolio decision, one can assume a longer-term investment period for which the wealth holder has to make his portfolio decision, e.g. 10 years. In addition, the assumption of non-interest-bearing, short-term deposits is not very realistic in a contemporary context. Thus, one may assume that these deposits provide an interest rate which corresponds to the short-term money market rate.

Once again, the portfolio decision is restricted to two options. The investor can either hold a 10-year bond or a sequence of 1-year deposits. In this case there is no uncertainty about the long-term interest rate. Instead, the uncertainty concerns the future short-term interest rates during the 10-year investment period. The decision problem of the investor is laid out in the expectations theory of interest rates.

Depending on this forecast, they will hold short-term deposits if the expected annual average interest rate of the consecutive short-term investments is higher than the annual interest rate of the bond i_{NB}. Assuming a short-term period of one year, this can be expressed by the following equation:

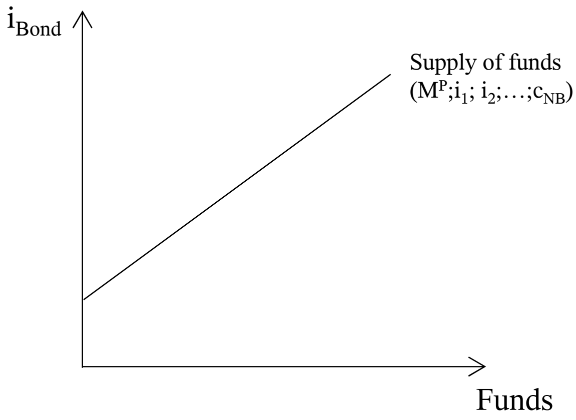
$$\sqrt[10]{(1+i_1)(1+i_2)...(1+i_{10})} > i_{NB}.$$

In this setting, the speculative or portfolio demand for money depends negatively on the interest rate of the bond and positively on the actual and expected short-term interest rates. The supply of funds in the bond market (B^S) is the difference between the individual money holdings available as a store of value (M^{SV}) and the speculative or portfolio demand for money (M^{PF}):

$$B^S = M^{SV} - M^{PF}.$$

For a given amount of M^{SV}, the supply of funds in the bond market is the mirror image of the portfolio demand for money. It is therefore determined by the same factors, i.e. positively by the bond interest rate and negatively by the actual and the expected future short-term interest rates. Thus, one can assume an upward sloping supply curve for funds in the bond market (which is simultaneously a demand curve for bonds) (see Figure 4.6). In addition to the actual and the expected short-term interest rates, one can assume that this curve also depends on the insolvency risk of the borrowers (c_{NB}) and on the total amount of money that is available for portfolio investments (M^P).

Figure 4.6: Supply of funds



In this model, the central bank can influence the supply of funds not only by setting the actual short-term rate, which is identical to its policy rate, but additionally by communicating its intentions with regard to the path of the future short-term interest rate ('forward guidance'). Thus, by lowering the policy rate and creating the expectation of future interest rate reductions or of the maintenance of low rates, it can shift the supply curve downwards.

The central bank can also shift the supply curve directly if it buys bonds from non-banks via open-market activities (quantitative easing). In this case the money stock increases, while in other transactions in the bond market it is only redistributed.

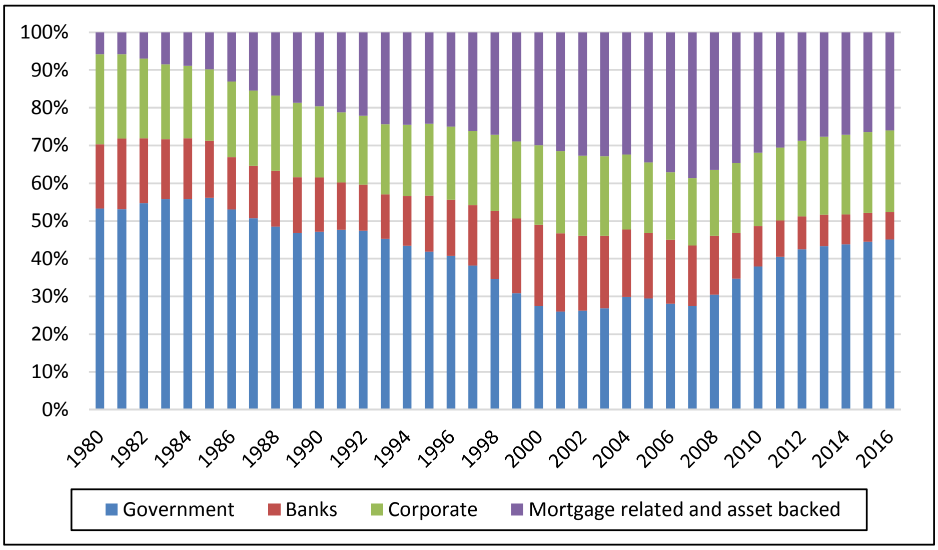
The supply of funds is also influenced by the credit creation of the banking system, which increases the amount of money that is available for portfolio holdings.[2] Again, this shifts the supply curve downwards.

4.3.2 What determines the demand for funds in the bond market?

On the demand side of the bond market, the most important borrower is the government. In the United States the private sector, with corporate borrowers and mortgage related bonds, also plays an important role. In addition, the banking sector borrows in the form of commercial paper and bankers' acceptances.

[2]Minsky (1975, p. 87): „An increase in the quantity of money relative to other assets and to the cash-payment commitments, decreases the liquidity premium on money, and thus the value of the liquidity embodied in different degrees in other assets and debts. This will tend to increase the money price of both debts which yield c and of capital assets which yield q, and it will increase the price of capital assets and debts which embody relatively little as compared to those assets and debts which owe a great deal of their market value to their liquidity."

Figure 4.7: Outstanding US Bond Market Debt categorized by issuer



Source: SIFMA.

This structure of the borrowers and the importance of borrowing for the purchase of existing real assets leads to an important insight: In contrast to the real analysis, the demand for loans in the bond market is not equivalent to (new) investment, even less so with respect to business investment.[3] Whereas in the real analysis the demand for funds is determined by the productivity of investments, the determinants in the monetary analysis depend on the type of borrowers.

- Governments borrow to finance shortfalls of revenue or to finance payments for social transfers (e.g. unemployment insurance). This borrowing is normally not sensitive to interest rate changes.

- Private investors borrow to finance the purchase of existing real assets. A major part of the borrowing carried out by private investors to finance new real assets is used for the purchase of real estate. The borrowing behavior of private investors depends primarily on the costs of borrowing as well as the economic situation.

[3]Keynes ([1930] 1971b, p.218): „The scale of investment will fluctuate for reasons quite distinct (a) from those which determine the propensity of the individual to save out of a given income and (b) from those physical conditions of technical capacity to aid production which have usually been supposed hither to be the chief influence governing the marginal efficiency of capital.“
Minsky (1975, p. 65): „The variations in the pace of investment, which are the proximate causes of fluctuations, are not due to variations in the technical productivity of capital or in the thriftiness of households. Even if technical productivity and thriftiness were well defined and stable, investment would still be liable to fluctuations. The 'reasons quite distinct' revolve around portfolio preferences, financing conditions, and uncertainty.“

- Banks borrow to reduce the degree of maturity transformation in their balance sheets. This borrowing is determined by expectations of future short-term interest rates.

Thus, 'real factors', above all the productivity of new investment in production capacities, are certainly not the sole determinant of the equilibrium rate of interest in bond markets. One could even argue that they are probably not a dominant factor.

4.4 Banks and the bond market in the monetary analysis

In the analytic framework of the monetary analysis, the supply and demand in the bond market exhibit both important similarities and key differences when compared with supply and demand in the banking system.

4.4.1 Differences

The main differences concern the ability of the banking system to create new money:

- In this process the balance sheet of the bank is extended and its leverage increases.
- As the maturity of bank loans is longer than that of deposits, the maturity transformation extends the duration of the bank balance sheet.
- In most cases, the borrower will use a loan to make a payment to another bank. This reduces the reserves of the credit creating bank with the central bank. Thus, if a bank provides a loan it has to abandon liquidity with the central bank.

The specific ability of banks to create money ex nihilo is reflected in specific regulations which do not exist for other economic agents:

- Capital requirements that are related to the bank's balance sheet (leverage ratio) or the bank's risk weighted assets set limits on the credit creation potential.
- Reserve requirements that are related to the bank's liability side (short-term deposits and liabilities) create a link between the expansion of their credit business and the amount of reserves that they must hold with the central bank.
- Liquidity requirements that require a net stable funding ratio between a bank's loans and its longer-term refinancing limit the potential degree of maturity transformation.

If loans are provided by non-banks in the bond market, existing money balances that are held with banks are redistributed:

- The balance sheet and the leverage of the lenders remains unchanged. They simply restructure the asset side of their portfolio.
- The duration of their portfolio increases as liquid money balances are exchanged for bonds with a longer maturity.
- Lending implies an abandonment of liquidity as the lender's liquid bank deposits decline.

There are no specific legal constraints for the typical holders of bonds (pension funds, mutual funds) concerning the maturity of their bond holdings. A major difference between the bank credit market and the bond market concerns the type of borrowers. Bank borrowers are typically private households and smaller firms. Bond market borrowers are large firms, the government, and also banks, which use the bond market for a reduction of the duration of their balance sheets. Thus, from the side of the borrowers there exists only a limited substitutability with regard to the two segments of the financial system.

4.4.2 Similarities

From the monetary perspective, the bond market also exhibits important similarities with the banking system. First and foremost, the interest rate is no longer a real rate and the supply of funds is mainly determined by a rate for short-term deposits and a rate for long-term bonds. Such an interest rate spread between a short-term refinancing rate and longer-term lending rate characterizes most post Keynesian models for the supply of bank loans. If one assumes that the deposit rate is more or less identical to the refinancing rate of banks (money market rate) and the policy rate of the central bank (e.g. the Federal Funds Rate), then the central bank has the ability to influence the supply in both markets.

Table 4.3: Overview Bank and bond market lending

	Bank lending	Bond market lending	Bank lending in the bond market
Lenders	Banks	Pension funds, Mutual funds	Banks
Supply	Creation of money: extension of balance sheets	Redistribution of money: asset swap	Creation of money: extension of balance sheets
Legal restrictions	Capital requirements, Liquidity requirements, Minimum reserves	None	Capital requirements, Liquidity requirements, Minimum reserves
Opportunity costs	Reduction in reserves: Money market rate	Reduction in money balances: deposit rate/money market rate	Reduction in reserves: Money market rate
Borrowers	Private households, firms, government	Large firms, banks, government	Large firms, banks, government
Leverage	High	Low	High
Central bank control	Indirect (policy rate)	Indirect (policy rate) and direct (quantitative easing)	Indirect (policy rate) and direct (quantitative easing)

4.5 The Model

Based on the previously described fundamentals, I develop a model for the monetary economy, which consists of a bank credit market and a bond market. The difference between the two markets stems from the fact that banks are originators of money, while in the bond market money balances are redistributed.

The cornerstone of the theoretical model is the banking sector, which grants credit to the non-banking sector and in this way provides money. Additionally, the banking sector demands a proportion of credit granted to the non-banking sector as high-powered money from the central bank, the amount of which is determined by the bank credit multiplier relationship. Once money is provided, suppliers in the bond market can provide credit to banks and non-banks in the bond market.

4.5.1 Model of the bank credit market

Bank Lending - Supply of Funds

The business model of banks is characterized by lending long and borrowing short, a strategy which is based on profit maximization (Minsky, 1980; Minsky et al., 1993; Fontana,

2003). The profitability of banks is determined by the interest rate spread between the interest rates for lending and borrowing (Spahn, 2013; Friedman, 2013, 2015).
To determine the profit function for a given bank, I identify the revenues and costs of bank's business. Banks grant credit to non-banks and generate revenues in this way. The primary costs stemming from granting credit are:

- Credit risk costs

  Credit risk costs arise primarily due to uncertainty about the redemption of credit. If a borrower is not able to repay a loan, the bank is obliged to depreciate this loan, which creates costs. In times of economic prosperity, the credit risk costs do not play a major role for banking business, because credit defaults rarely occur. However, when the economy is in turmoil, as was the case during the recent financial crisis, the banking sector commonly faces higher costs resulting from loan defaults.

- Interest rate risk

  The interest rate risk stems from banks' business model of lending long and borrowing short. In the balance sheet a maturity mismatch between the asset and the liability sides occurs, where on the asset side long-term loans and on the liability side short-term refinancing (deposits) are recorded. Assuming that the central bank is able to control the short-term interest rate, the costs for short-term refinancing adjusts immediately if the central bank changes the refinancing rate. However, the revenues generated on the asset side adjust in a limited way due to fixed rate loan contracts. Thus in order to control the risk of interest rate changes, banks are obliged to refinance a share of the asset side via bonds, which are longer term than deposits. This maturity matched refinancing is defined by regulators via the Net Stable Funding Ratio and the Liquidity Coverage Ratio in the regulatory framework of Basel III.

- Capital requirements

  Banks' business model is characterized by high indebtedness, implying that capital losses have a profound effect on the stability of the banking sector. In order to strengthen each individual bank, the regulatory framework is designed such that banks are required to hold a share of assets as equity (risk-weighted assets to common equity according to Basel III). This capital requirement is necessary for the absorption of capital losses. Thus, each bank is able to deal with capital losses independently without any contagion risk for the entire banking sector.

Based on the described revenues and costs, I derive the profit function for one representative bank j as follows:

$$\pi_B^j = i_B Cr_{B/NB}^j - i_D D^j - i_R(Cr_{CB/B}^j - R^j) - i_E E^j - i_{NB} B^j - O^j - V_B^j,$$
$$\text{with } V_B^j = c_B (Cr_{B/NB}^j)^2.$$

The revenues of the bank stem from credit business, which means lending money to non-banks $Cr_{B/NB}$ at price i_B. The refinancing costs consist of the interest paid on deposits $i_D D$, on net refinancing from the the central bank $i_R(Cr_{CB/B} - R)$, and on refinancing in the equity market $i_E E$ and in the bond market $i_{NB} B$. There also exist operational costs O, comprising the costs for monitoring and screening. Furthermore, credit risk costs V_B arise, which depend negatively on and increase disproportionately with income (Fuhrmann, 1987; Cosimano, 1988; Freixas and Rochet, 2008).

Taking a closer look at the business of representative bank j, I consider its balance sheet:

Table 4.5: Balance sheet of bank j

Assets	Liabilites
Credit from Banks to Non-banks $Cr_{B/NB}$	Equity E
	Bonds B
Reserves R	Deposits D
	Credit from Central Bank to Banks $Cr_{CB/B}$

The refinancing sources of the bank are recorded on the liability side and consist of equity, bonds, deposits and credit from the central bank. The bank uses these funds to grant credit as well as to meet the minimum reserve requirement set by the central bank.

From the balance sheet identity I derive the relationship

$$Cr_{CB/B}^j - R^j = Cr_{B/NB}^j - D^j - E^j - B^j,$$

which I insert into the profit equation. In addition, I insert the equity requirement, defined as a proportion of equity relative to credit granted to non-banks $\eta^E = \frac{E^j}{Cr_{B/NB}^j}$, and the regulatory requirement, defined as a ratio of bonds to credit to non-banks $\eta^B = \frac{B^j}{Cr_{B/NB}^j}$

which is meant to reduce the interest rate risk. Taken together, these ratios and the previously identified relationship yield

$$\pi_B^j = (i_B - i_R - \eta^E(i_E - i_R) - \eta^B(i_{NB} - i_R))Cr_{B/NB}^j - (i_D - i_R)D^j - O^j - c_B(Cr_{B/NB}^j)^2. \tag{4.1}$$

Taking the first derivative of this equation (Equation 4.1) with respect to the credit volume $Cr_{B/NB}^j$, I derive the credit supply of representative bank j

$$\frac{\partial \pi_B^j}{\partial Cr_{B/NB}^j} = (i_B - i_R - \eta^E(i_E - i_R) - \eta^B(i_{NB} - i_R)) - 2c_B Cr_{B/NB}^j \stackrel{!}{=} 0$$

$$\Leftrightarrow Cr_{B/NB}^j = \frac{(i_B - i_R) - \eta^E(i_E - i_R) - \eta^B(i_{NB} - i_R)}{2c_B}.$$

I receive the credit supply of the banking sector by summing the credit supply for n homogeneous banks

$$Cr_{B/NB}^S = \sum_{j=1}^{n} Cr_{B/NB}^j = \frac{((i_B - i_R) - \eta^E(i_E - i_R) - \eta^B(i_{NB} - i_R))n}{2c_B}. \tag{4.2}$$

Bank Borrowing - Demand for funds

Borrowers in the bank credit market are represented by firms, governments and households who seek funding for their investments or engage in consumption activities (Minsky et al., 1993). Modeling of credit demand is similar to money demand. Both require the provision of liquid funds beforehand in order to carry out transactions. The willingness of lenders in the bank credit market to finance borrowers' business activities depends primarily on the economy's income. Additionally, the interest rate on credit, which represents costs, negatively influences credit demand. The bond market acts as an alternative source for borrowers to acquire liquid funds for their investments. Thus, the substitution effect of the bond market is evaluated by considering the price differential between bank credit and bond market borrowing. The potential substitutability of the bond market depends on the type of borrower. Small and medium sized firms are associated with borrowing in the bank credit market due to the prohibitively high entrance costs of the bond market. However, large firms, and in particular sovereigns, are able to choose between two types of financing. In consideration of these determinants, I define the demand for bank credit as

$$Cr_B^D = a - bi_B + d(i_{NB} - i_B) \tag{4.3}$$

$$\text{with } a = \mu + \gamma Y,$$

where Y denotes income, i_B the price for bank loans, and $(i_{NB} - i_B)$ the price differential, included to capture the substitution effect. Based on the work of Ledvina and Sircar (2011), I define three types of substitution between the bank credit and bond market:

- independent loans $d = 0$: The demand for bank credit is not affected by the bond market interest rate. Thus, no substitution is possible.

- differentiated loans $d \in [0; \infty]$: The price of bonds affects the demand for bank credit. Competition exists between these markets.

- homogeneous loans/perfect substitutes $d \to \infty$: Bank credit and bonds are perfect substitutes. Theoretically, if there are price differences between the two markets then the entire demand is directed towards the market which provides the lowest price. However, due to institutional conditions the bank credit market functions as a prerequisite for the bond market. Money is created in the bank credit market and is then redistributed in the bond market.

Bank credit market equilibrium

The equilibrium in the bank credit market is determined by the equality of the supply of bank loans (Equation 4.2) and the demand for bank loans (Equation 4.3). Assuming $n = 1$ for the purpose of simplicity, the equilibrium credit volume $Cr^*_{B/NB}$ and the bank credit interest rate i^*_B are defined as

$$Cr^*_{B/NB} = \frac{a - (b+d)(i_R + \eta^E(i_E - i_R) + \eta^B(i_{NB} - i_R))}{1 + 2c_B(b+d)} \text{ and} \tag{4.4}$$

$$i^*_B = \frac{2c_B(a + d i_{NB}) + (i_R + \eta^E(i_E - i_R) + \eta^B(i_{NB} - i_R))}{1 + 2c_B(b+d)}. \tag{4.5}$$

Bank credit multiplier

The bank credit multiplier represents the balance sheet mechanics of banking. As well as granting credit to non-banks, banks also demand a fraction of credit as high-powered money from the central bank. In contrast to the common money multiplier theory, banks are not constrained by high-powered money, because the central bank provides as much high-powered money as the banking sector demands at a fixed rate (refinancing rate). However, the bank credit multiplier includes information about the share of credit granted as high-powered money. Thus, I define the bank credit multiplier m_B as

$$m_B = \frac{Cr_{B/NB}}{H},$$

where $Cr_{B/NB}$ is credit granted to non-banks and H is the amount of high-powered money. Inserting money, consisting of cash C and deposits D, and high-powered money, composed of cash C and reserves R, and taking into consideration that $Cr_{B/NB} = \frac{M}{(1-\eta^E-\eta^B)}$, I receive

$$m_B = \frac{Cr_{B/NB}}{H} = \left(\frac{C+D}{R+C}\right)\left(\frac{1}{1-\eta^E-\eta^B}\right).$$

I further rearrange the equation, taking into account that a fixed share of deposits is held in cash

$$C = h * D,$$

where h represents the cash holding coefficient of the private sector, and express the reserve requirement as

$$R = r * D,$$

where r is the minimum reserve requirement set by the central bank. Taking this information into account, I define the bank credit multiplier as

$$m_B = \frac{Cr_{B/NB}}{H} = \left(\frac{1+h}{h+r}\right)\left(\frac{1}{1-\eta^E-\eta^B}\right).$$

The first ratio $(\frac{1+h}{h+r})$ is the standard money multiplier, which is greater than one. The second ratio $(\frac{1}{1-\eta^E-\eta^B})$ is also greater than one, because $\eta^E + \eta^B < 1$. Both ratios together result in a bank credit multiplier greater than one.

Banks are able to restructure their balance sheet in order to adapt, e.g. to changing regulatory requirements. Observing an increase in either equity η^E or bonds η^B refinancing under the assumption of a fixed amount of credit reported on the asset side, the amount of high-powered money required decreases due to an increase in the bank credit multiplier relationship.

Market for High-powered Money

As the monopolistic supplier of high-powered money, the central bank is able to set the refinancing rate according to its respective target (e.g. inflation rate or employment). The market for high-powered money indicates the demand for high-powered money from the banking sector for different refinancing rates. In order to derive a functional form of the demand for high-powered money, I assume a linear function for which two points are required. The first point is defined as the amount of high-powered money that corresponds to the equilibrium amount of credit granted to non-banks, as well as the respective refinancing rate i_{R_0}. Next I derive a second point, representing the prohibitive price of demand for high-powered money, which is equivalent to the prohibitive price of bank credit demand minus the spread for bond and equity refinancing from the banking sector, because at this point the bank credit market breaks down. Taking these two points into account, I derive the following demand for high-powered money equation:

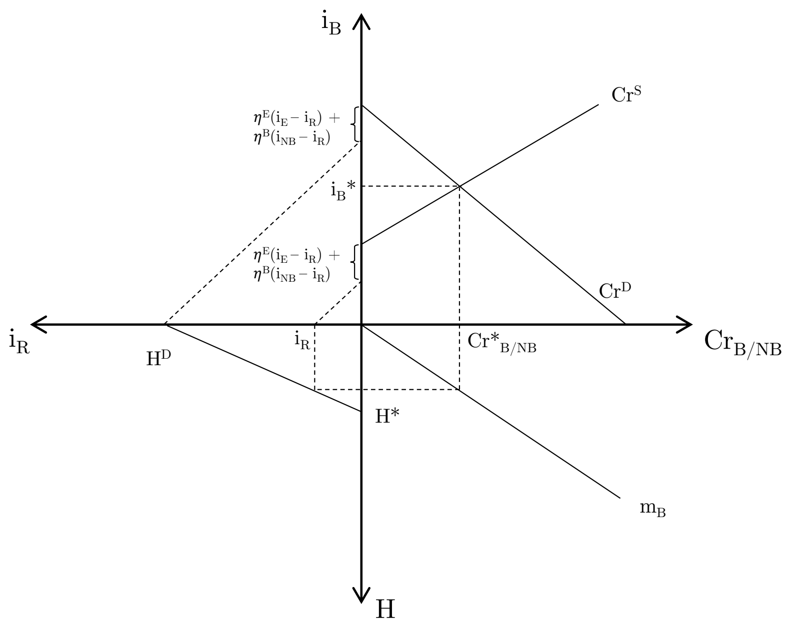
$$H^D = e\frac{Cr^*_{B/NB}}{m_B}(e-1) - \frac{m_B}{Cr^*_{B/NB}}(e-i_{R_0})i_R \tag{4.6}$$

$$\text{with } e = \left(\frac{a+di_{NB}}{b+d}\right) - \eta^E(i_E - i_R) - \eta^B(i_{NB} - i_R).$$

Graphical illustration

Following the analytic description of my banking model, I illustrate the bank credit market and the market for high-powered money, which are linked by the bank credit multiplier. In the first quadrant, the intercept of the credit supply curve Cr^S is determined by the refinancing rate i_{R_0} and the additional costs for refinancing in the bond and equity markets. The credit supply curve extends positively as a result of the increasing credit default costs. The slope of the credit demand function Cr^D is negative. The intersection of the two curves determines the equilibrium amount of credit $Cr^*_{B/NB}$ and the interest rate i^*_B. In the second quadrant, I define the equilibrium amount of high-powered money H^* based on the bank credit multiplier. Combining this with the refinancing rate i_{R_0}, the first point for the derivation of the demand for high-powered money function is thus defined. The prohibitive price for high-powered money is equal to the prohibitive price for bank credit minus the spread for bond and equity refinancing, and is shown as a 45°-line in the fourth quadrant. The prohibitive price for high-powered money comprises my second point for the derivation of the negatively sloped high-powered money demand curve H^D.

Figure 4.8: Bank credit market



4.5.2 Bond market

After the creation of money in the bank credit market, the agents in the bond market are able to redistribute the existing money stock, if the money holders are willing to abandon liquidity.[4]

Lending liquid funds - Supply side

The willingness to abandon liquidity depends on the interest rate spread between the price for holding bonds and the price for holding money as deposits, because I assume that money holders have only these two options with regard to how they may use their funds. Thus, in this case profitability is determined similarly to that of banks. The lending of liquid funds by money holders also brings about costs, however they differ in magnitude from those of the banking sector:

- Credit risk costs

  As in the banking sector, lenders in the bond market also face credit risk costs if borrowers are not able to repay loans. This is more likely to occur in times of recession. I assume that borrowers in the bank credit market are primarily represented by households as well as small and medium sized firms. These entities are characterized

[4] I assume that no additional funds from the banking market flow into the bond market.

by higher credit default risk than borrowers in the bond market, which comprise governments, banks, and large companies.[5]

- Interest rate risk
  Lenders in the bond market have to take interest rate changes over their investment horizon into account, because interest rate changes lead to fluctuating bond prices. For example, when an investor expects interest rates to increase in the future, they must demand a higher interest rate to ensure that they are compensated for future bond price losses.

- Capital requirements
  In contrast to the banking sector, the suppliers of liquid funds in the bond market are not subject to regulation. Thus, lenders in the bond market do not need to consider capital requirements.

Taking the revenues and costs of the supply side into account, I derive the following profit function for a representative lender k

$$\pi^k_{NB} = i_{NB} Cr^k_{NB} - i_D Cr^k_{NB} + (\frac{i_{NB}}{i^e_{t+1}} - \frac{i_{NB}}{i_t}) Cr^k_{NB} - I^k - V^k_{NB}$$
$$\text{with } V^k_{NB} = c_{NB}(Cr^k_{NB})^2.$$

The revenues stem from credit business $i_{NB}Cr^k_{NB}$, where i_{NB} represents the interest rate for credit in the bond market and Cr^k_{NB} the amount of credit granted. The costs which arise from granting credit are the opportunity costs $i_D Cr^k_{NB}$ as well as costs stemming from the risk of interest rate changes over the investment horizon, the latter of which may be recognized when considering the potential for bond price losses $(\frac{i_{NB}}{i^e_{t+1}} - \frac{i_{NB}}{i_t})Cr^k_{NB}$. Additional costs consist of information costs I^k, e.g. to cover the evaluation of financial investments, and credit risk costs V^k_{NB}, which are similar to the credit risk costs of the banking sector. For simplicity, I assume that the bonds are priced at par value, which leads to $i_{NB} = i_t$, and further assume that the interest rates for refinancing at the central bank and for deposits are identical $(i_D = i_R)$[6]. This yields

$$\pi^k_{NB} = (i_{NB} - i_R) Cr^k_{NB} + (\frac{i_{NB}}{i^e_{t+1}} - 1) Cr^k_{NB} - I^k - c_{NB}(Cr^k_{NB})^2. \tag{4.7}$$

[5]For non-financial corporations, Carbo-Valverde et al. (2012) show that the default risk decreases if the firm size increases.

[6]This assumption is based on the high level of competition in the money market, where the interest rate for deposits is only marginally higher than the refinancing rate at the central bank in conventional times.

Deriving the credit supply for one representative lender k, I differentiate the profit function with respect to the credit volume Cr^k_{NB} and solve for this credit amount:

$$\frac{\partial \pi^k_{NB}}{\partial Cr^k_{NB}} = (i_{NB} - i_R) + (\frac{i_{NB}}{i^e_{t+1}} - 1) - 2c_{NB}Cr^k_{NB} \stackrel{!}{=} 0$$
$$\Leftrightarrow Cr^k_{NB} = \frac{(i_{NB} - i_R) + (\frac{i_{NB}}{i^e_{t+1}} - 1)}{2c_{NB}}.$$

I assume that the lenders in the bond market are homogeneous, and therefore the total credit supply for m suppliers in the bond market is

$$Cr^S_{NB} = \sum_{k=1}^{m} Cr^k_{NB} = \frac{((i_{NB} - i_R) + (\frac{i_{NB}}{i^e_{t+1}} - 1))m}{2c_{NB}}. \tag{4.8}$$

Borrowing liquid funds - Demand side

On the demand side I assume homogeneous borrowers, and as such do not distinguish between the various determinants which affect the decisions of sovereigns, banks, and non-financial corporations. The determinants of borrowing liquid funds are income, the cost for credit in the bond market, and the substitution option for acquiring funds in the bank credit market, defined as the spread between the interest rate for bank credit and bonds. This yields

$$Cr^D_{NB} = a - bi_{NB} + d(i_B - i_{NB}), \tag{4.9}$$
$$\text{with } a = \mu + \gamma Y.$$

Equilibrium in the bond market

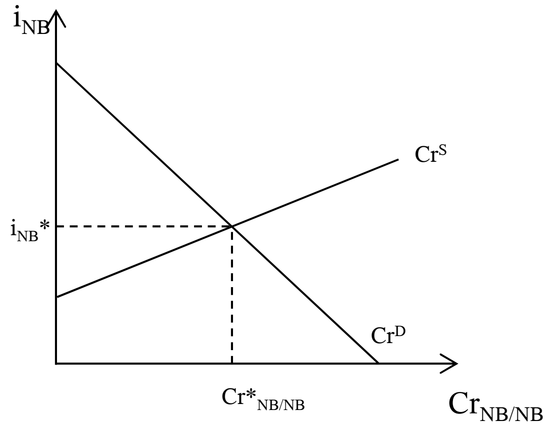
I obtain the equilibrium amount of credit and the equilibrium interest rate by setting the supply of liquid funds (Equation 4.8) equal to demand (Equation 4.9) under the assumption of $m = 1$. Thus, I derive

$$Cr^*_{NB} = \frac{(a + di_B)(\frac{i^e_{t+1} + 1}{i^e_{t+1}}) - (b + d)(i_R + 1)}{\frac{i^e_{t+1} + 1}{i^e_{t+1}} + 2c_{NB}(b + d)}$$
$$i^*_{NB} = \frac{2c_{NB}(a + di_B) + i_R + 1}{\frac{i^e_{t+1} + 1}{i^e_{t+1}} + 2c_{NB}(b + d)}.$$

Graphical illustration

I again begin the graphical depiction of the bond market with the credit supply curve Cr^S. The intercept of the credit supply is determined by the refinancing rate of the central bank as well as expectations regarding the interest rate. The credit supply curve extends positively from the intercept due to credit risk costs and interest rate expectations. The linear demand curve runs negatively on the coordinate plane. The intersection of the demand for and supply of liquid funds determines the equilibrium amount of credit Cr^*_{NB} and the equilibrium interest rate i^*_{NB}.

Figure 4.9: Bond market



4.5.3 Bank credit market and bond market

Following the derivation of the equilibriums for bank credit and for the bond market, I compare these two markets and highlight the differences between them.

Assuming the convergence of the costs for both sectors, the model implies that both markets are symmetric, i.e. the equilibrium amount of credits and the equilibrium interest rates converge. However, as I derived from the model, the banking sector bears higher costs than do suppliers in the bond market.

Due to the structure of borrowers in both markets, banks grant credit to borrowers who are more likely to default on their loans (see, e.g. Bester, 1985; Berlin and Mester, 1992; Tymoigne, 2014). Thus, the **credit default costs** in the bank credit market appear to exceed the corresponding costs for the suppliers in the bond market.

Furthermore, both types of lenders face **interest rate risk**. The banking sector is obliged to restructure their balance sheet in order to reduce the maturity mismatch. The maturity-matched refinancing can be interpreted as insurance against future interest rate changes.

However, refinancing costs increase as a result of the maturity-matched refinancing. Similarly, the suppliers in the bond market also account for potential interest rate changes in their pricing in order to avoid bond price losses in the future. As both suppliers consider and adjust for interest rate risk, I cannot identify a clear-cut difference between them with regard to this cost component.

The main difference between the costs faced by both suppliers stems from **capital requirements**. Whereas, banks are obliged to hold a fraction of credit in equity, which is more expensive than any other form of refinancing, the suppliers in the bond market are not required to do so.

The result of these different types of costs is a higher interest rate for bank credit than for bonds. However, institutional factors ensure the coexistence of both markets, since the money creation function of banks is a prerequisite for the existence of the bond market.

4.6 Monetary policy

The central bank monopolizes the provision of high-powered money to banks and also sets the price for high-powered money. As the recent literature emphasizes, bank lending is not constraint by high-powered money (Disyatat, 2011; McLeay et al., 2014; Jakab and Kumhof, 2015). I have already addressed this fact in my model.

The goal of this section is to quantify the effects of monetary policy in both the bank credit and bond markets.

Conventional monetary policy

The central bank is able to stimulate the bank credit and bond markets by controlling the refinancing rate. The refinancing rate is an important determinant of the bank credit supply because the refinancing rate represents one cost component of the banking system (see Chapter 3). The refinancing rate also helps determine the opportunity costs of holding money for lenders of liquid funds in the bond market.[7] The opportunity costs influence the choice of whether to hold money or lend it. Via these two channels, the central bank is able to control both financing markets by manipulating the refinancing rate.

[7] I assume equality of the refinancing rate and the interest rate for deposits.

To determine the effect of the refinancing rate on the bond and bank credit rates, I take the first derivative of the corresponding equilibrium price with respect to the refinancing rate:

$$\frac{\partial i_B^*}{\partial i_R} = \frac{1 - \eta^E - \eta^B + \dfrac{(\eta^B + 2c_B d)}{\dfrac{i_{t+1}^e + 1}{i_{t+1}^e} + 2c_{NB}(b+d)}}{1 + 2c_B(b+d)},$$

$$\frac{\partial i_{NB}^*}{\partial i_R} = \frac{1}{\dfrac{i_{t+1}^e + 1}{i_{t+1}^e} + 2c_{NB}(b+d)}.$$

Both interest rates are affected positively. If the central bank practices a restrictive monetary policy, i.e. it increases the refinancing rate, and all other conditions remain the same, the costs for both sectors increase. The result is an increase in both sectors' interest rates, as well as a corresponding decrease in the amount of credit granted. Investigating the quantitative effect of monetary policy reveals effects of less than one. These effects stem from the role of interest rate expectations for lenders in the bond market and from that of refinancing in the bond and equity markets for banks. This result can be interpreted as a weakening of the monetary policy transmission channel. Specifically, regulatory requirements imply this diminishing effect for the bank credit market, and this can be interpreted as a trade off between monetary policy and regulation.

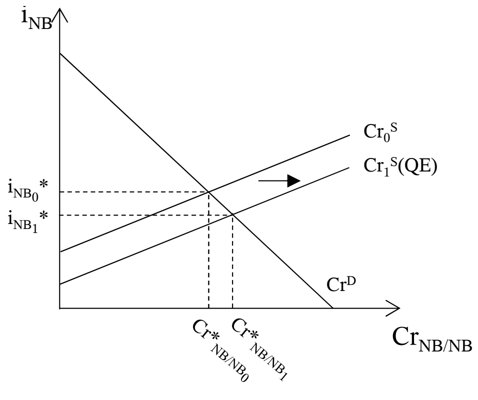
Unconventional monetary policy

The central banks in the US, UK, Japan, and Euro area have implemented long-term refinancing operations and quantitative easing in reaction to the financial and sovereign debt crisis.

Following the financial turmoil, central banks tried to revive the slumping bond market, which at that point was characterized by rocketing bond yields, via quantitative easing. In order to control long-term bond yields, central banks started to purchase bonds in the bond market, which means that the central banks acted as additional suppliers in the bond market.[8] In my model this effect is captured as a supply shock in the bond market. Thus, assuming that other conditions stay the same, additional supply leads to a rightward shift of the supply curve ($Cr_0^S \rightarrow Cr_1^S$) which yields lower interest rates in the bond market ($i_{NB_0} \rightarrow i_{NB_1}$).

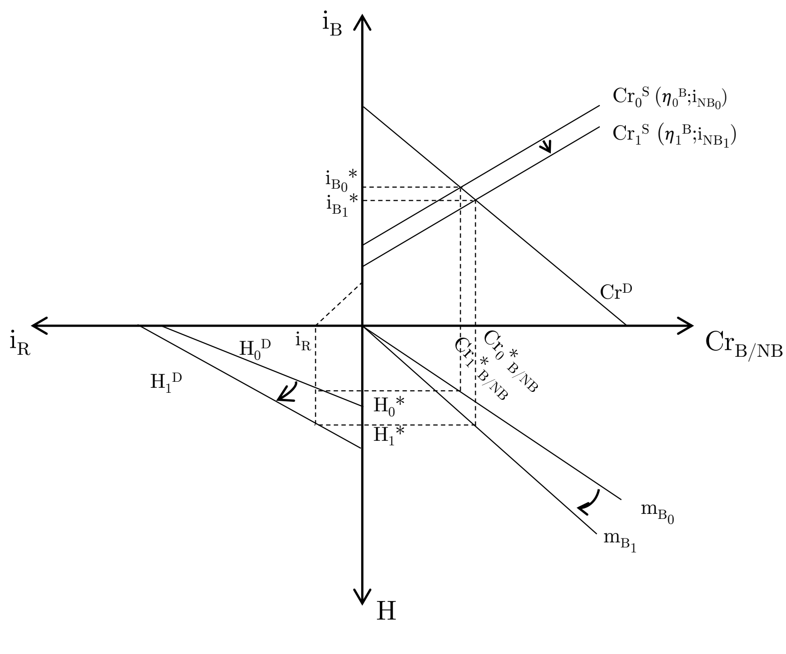
[8]As described in Chapter 5, the announcements of QE programs have already influenced the agents in the bond market which works via credit risk and interest rate expectations in my model.

Figure 4.10: QE in the bond market



In addition to QE, and in response to the scarcity of interbank and bond market refinancing of banks, the central banks tried to overcome this refinancing drought by establishing long-term refinancing operations meant to strengthen the banking sector. In my model, these long-term refinancing operations lead to a decline in the share of borrowing that the banking system must conduct in the bond market, because the banking system is able to alleviate the maturity mismatch with lower-yielded central bank loans. The gross effect of the bank credit market comprises the decline in the bond yield ($i_{NB_0} \rightarrow i_{NB_1}$) for refinancing in the bond market as well as a shift from bond refinancing to central bank credits ($\eta_0^B \rightarrow \eta_1^B$), which leads to lower costs for the banking sector and its subsequent provision of bank credit at lower interest rates ($i_{B_0} \rightarrow i_{B_1}$).

Figure 4.11: QE in the bank credit market



4.7 Interaction between the bank credit market and the bond market

The bank credit and bond markets are connected via two channels. On the supply side, banks have the opportunity to refinance their business via bonds, an instrument they employ to reduce the maturity mismatch. On the demand side, borrowers are able to choose either bank credit or bonds. However, there are limits to this freedom of selection because households and small and medium sized firms are not able to obtain funds in the bond market.

Due to the interconnectedness of the bank credit and bond markets, the two markets are able to influence one another. I therefore derive reaction functions for the banking sector and the lenders in the bond market in order to capture these spillover effects between the two markets. These effects are of major relevance in the context of unconventional monetary policy.

4.7.1 Derivation of Reaction functions

I consider a simultaneous solution for both sectors, each of which takes the behavior of the other sector into account. Both sectors seek to maximize their profits with respect to the corresponding interest rate. They utilize their respective demand function in order to derive a reaction function. With this in mind I adopt an analytic approach, plugging each credit demand function into the corresponding profit function and maximizing these functions with respect to the relevant interest rates. For the banking sector, I insert the credit demand function for bank credit (Equation 4.3) into the profit function for the banking sector (Equation 4.1). Taking the first derivative of the profit function with respect to the interest rate for bank credits i_B and solving for i_B, I obtain the reaction function for the banking sector dependent on the bond market interest rate, i_{NB}

$$\begin{aligned} i_B(i_{NB}) =& \frac{a + (b+d)(2ac_B + i_R(1-\eta^B-\eta^E) + \eta^E i_E)}{2(b+d)(1+c_B(b+d))} \\ &+ i_{NB}\frac{d + (\eta^B + 2dc_B)(b+d)}{2(b+d)(1+c_B(b+d))}. \end{aligned} \tag{4.10}$$

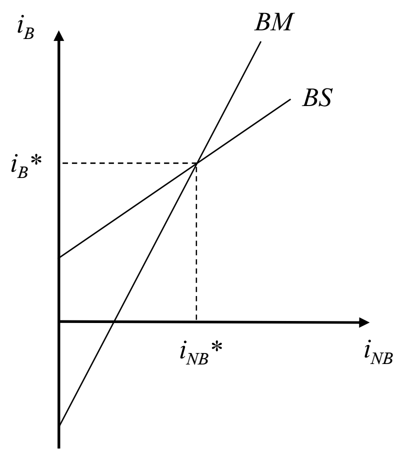
In order to derive the reaction function for lenders in the bond market, I plug the bond market credit demand (Equation 4.9) into the profit function for lenders in the bond market (Equation 4.7). I then take the derivative with respect to the interest rate of bonds i_{NB}

and solve for this variable. The reaction function for the bond market is therefore

$$i_{NB}(i_B) = \frac{a + (b+d)(2ac_{NB} + i_R - \dfrac{i^e_{t+1} + 1}{i^e_{t+1}})}{2(b+d)(1 + c_{NB}(b+d))} + i_B \frac{d + 2dc_{NB}(b+d)}{2(b+d)(1 + c_{NB}(b+d))}. \tag{4.11}$$

As previously mentioned, I assume that the banking sector bears higher costs than do suppliers in the bond market. This fact implies a steeper reaction function for bond market suppliers (BM) than for the banking sector (BS) (see Figure 4.12), the result of which is a higher interest rate for bank credit than for bonds ($i^*_B > i^*_{NB}$). I obtain the equilibrium interest rates by locating the intersection of the two reaction functions.

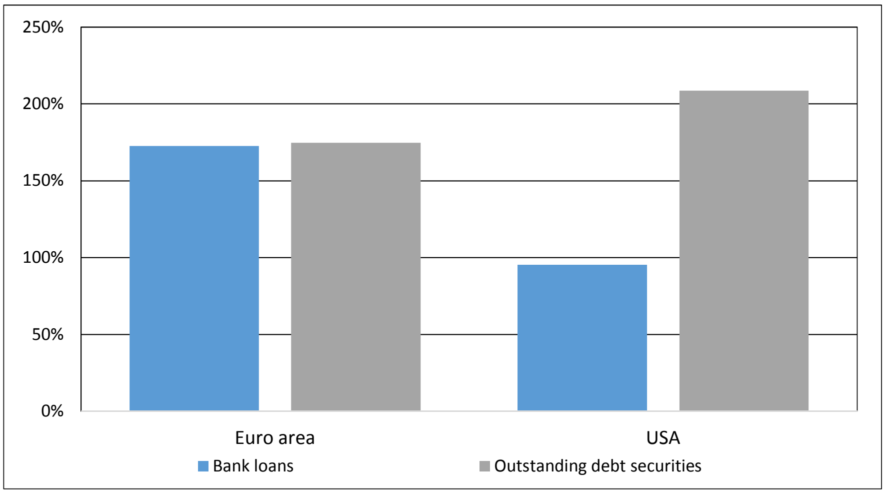
Figure 4.12: Reaction functions



4.7.2 Spillover Effects

In this section, I focus on the role of substitution elasticity in order to capture the effects of changes in one market on the other. Specifically, I observe how the emergence of QE in the bond market impacts the bank credit market. In my model this spillover effect depends on the substitution elasticity d, which can be interpreted as the level of competition between the two markets. A higher value for d indicates stronger competition. To evaluate the spillover effects, I consider the cases of the American and euro area markets. The USA may be characterized as market based, meaning that more financing is received from the bond market, while the euro area is bank based, as bank credits play a more dominant role (Levine, 2002). This structure is also evident when comparing volumes traded in the markets in the USA with those in the euro area (see Figure 4.13).

Figure 4.13: Structure of the financial systems in the USA and the euro area

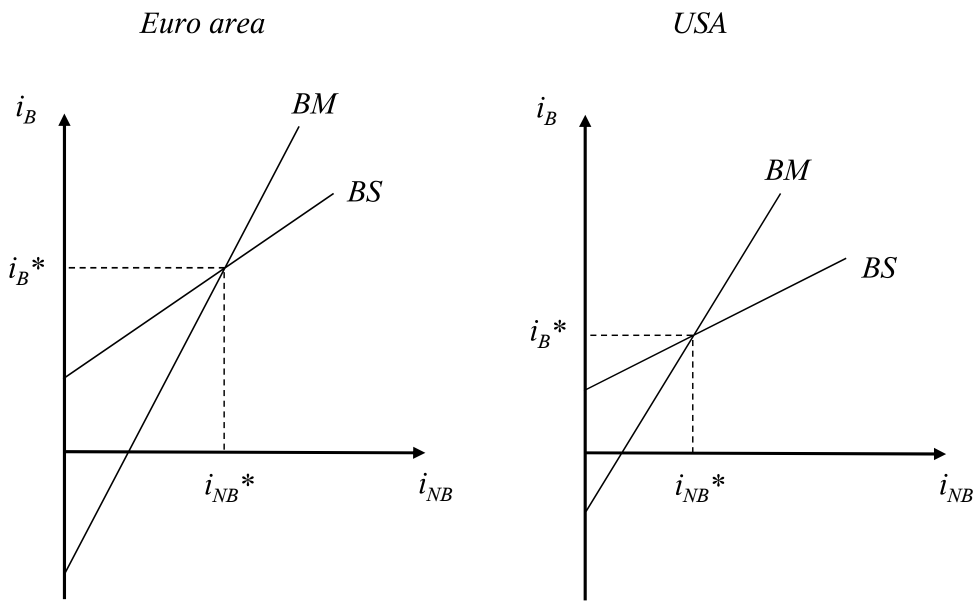


Source: ECB Statistical Pocket Book and own calculations.

Notes: The figures are calculated as ratios to GDP for the year 2013.

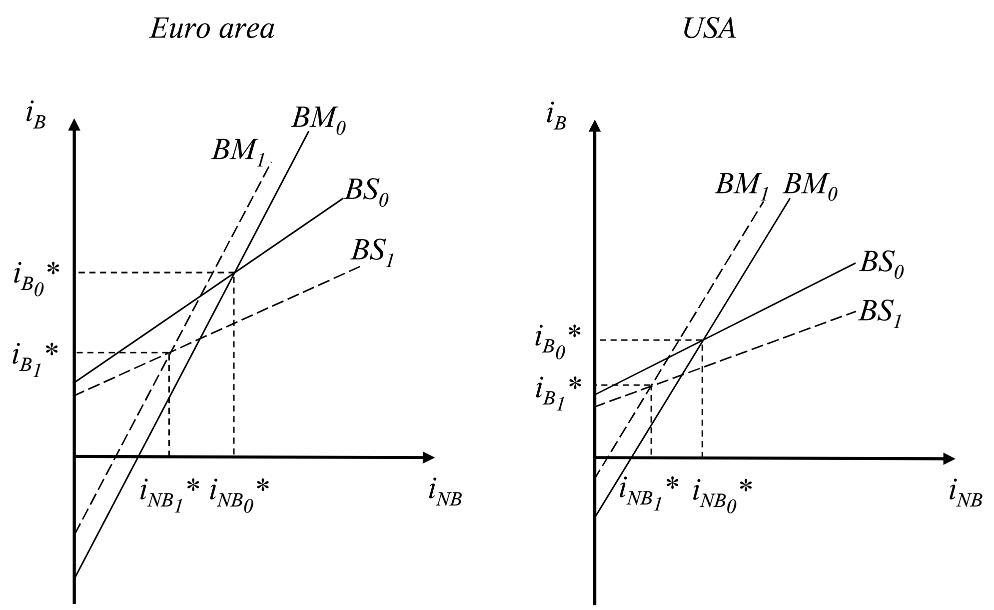
In the USA, outstanding debt securities account for more than twice as much of lending activities than do bank loans, reflecting its market-based system. The euro area, on the other hand, exhibits a balanced relationship between the two markets. From these figures, I conclude that the American system is characterized by higher levels of competition between the sectors than the euro area system. Thus, in my model, I infer that the substitution elasticity in the USA is greater than that in the euro area ($d_{USA} > d_{Euro}$).

Figure 4.14: Reaction functions for the USA and the Euro area



I illustrate these cases in Figure 4.14, where I observe a larger difference between the bank credit and bond market interest rates in the euro area than in the USA. I attribute this finding to greater competition between the two markets in the euro area. I proceed to evaluate the effects of long-term refinancing operations as well as QE for these two systems (see Figure 4.15). The long-term refinancing measures affected the banking sector in allowing banks to reduce their maturity mismatch via these measures which were less costly than maturity-mismatch refinancing in the bond market. I capture this effect as a decrease in the share of bond refinancing η^B which shifts and rotates the reaction function for banks ($BS_0 \rightarrow BS_1$). QE also functions via interaction with the bond market. The central bank shocks the bond market by entering it as an additional supplier, thus shifting the reaction function for lenders in the bond market to the left ($BM_0 \rightarrow BM_1$).
When considering the euro area, I identify an initial convergence of the bond and bank credit market interest rates. In the USA, where I assumed a smaller initial gap between bond and bank credit interest rates, both interest rates decrease at the same pace.

Figure 4.15: QE in the USA and the Euro area



My model indicates a decline in interest rates for both regional areas, highlighting that US banks must react more strongly than euro area banks to adjustments in the bond market due to the greater competition which I assume for the US markets.

4.8 Conclusion

In the theoretical framework of a monetary economy, where banks act as creators of money and the bond market serves as a space for its redistribution, the roles of banks and the bond market are diametrically opposed to those of the real analysis approach. The redistributive function of the bond market has been completely neglected in the literature regarding the monetary paradigm.

To address this gap in the literature, I describe the determinants of the supply of and demand for funds in the bond market and use these concepts to construct a model for the financial system consisting of a bank credit market and a bond market. Banks create money by the act of lending while simultaneously demanding high-powered money according to the bank credit multiplier, a process which reveals the balance mechanics of banking. Once money is created it flows into the bond market, where money balances are redistributed and in this way create multiple instances of credit.

quantitative easing necessitates consideration of the bond market in a monetary economy. Following the financial crisis, central banks acted as an additional supplier in the bond market in order to control long-term bond yields. Quantitative easing also has an indirect effect on the bank credit market due to the fact that the bank credit and bond markets are interconnected through both the supply and the demand side. I am able to capture these spillover effects in my model, where I evaluate the effects for the USA and the Euro area. Implementation of my model shows that for both geographical regions, bond market and bank credit market interest rates have decreased as a result of unconventional monetary policy measures.

Chapter 5

A Theoretical and Empirical Assessment of Quantitative Easing in the Eurozone[1]

5.1 Introduction

"The problem with QE is it works in practice, but it doesn't work in theory", Bernanke answered when asked about the effectiveness of quantitative easing (QE) in 2012.
So far, several empirical studies, mainly dealing with the programs by the Fed and the BoE, have shown that QE does indeed have the desired effects, especially in terms of lowering sovereign bond yields. These studies to a large extent identify and disentangle various channels of transmission of QE on sovereign bond yields.[2]
In the Euro area, where the European Central Bank's (ECB) unconventional measures were mainly aimed at reducing inter-country sovereign bond spreads in response to the financial crisis, the sovereign-banking nexus, and the sovereign debt crisis, the focus of literature lies on bond spread reduction. A significant impact of QE, in terms of decreasing bond spreads relative to the German Bund, has been found for the Eurozone by Falagiarda and

[1] This chapter is based on joint work with Camilla Simon.
[2] For a comprehensive overview see Krishnamurthy and Vissing-Jorgensen (2011).

Reitz (2015), Szczerbowicz (2015), Gerlach-Kristen (2015), and Eser and Schwaab (2016) in the context of programs prior to 2015.

In analyzing sovereign bond yields instead of spreads and therefore capturing the effects of QE for German Bunds as well, our paper best aligns to the papers by Altavilla et al. (2015) and De Santis (2016), who identified an overall negative reaction of sovereign bond yields resulting specifically from the announcement of the ECB's Asset Purchase Programme (APP) in January 2015 and additionally analyzed several transmission channels for the negative effect on long-term yields in the Euro area. To the best of our knowledge, thus far no paper has evaluated the entire range of QE programs conducted by the ECB both theoretically and empirically.

We begin our paper by providing an overview of the existing monetary policy tools of the ECB in section 2. After analyzing the literature on ECB programs in section 3 in line with the most-cited papers on US and UK monetary policy, in section 4 we first contribute to the existing literature by developing a theoretical model that is capable of depicting the effects of QE on the financial system and its mere announcement by considering two transmission channels (the term premium channel and credit risk channel). For this purpose, we distinguish two markets with the financial system. One is the bank credit market, where banks supply credit and in this way create money.[3] The other is the bond market, where non-banks redistribute the money created by the banking sector by purchasing bonds, and in doing so implicitly grant loans to banks and non-banks. In evaluating the effects of QE, we identify non-bank suppliers of credit as the counterparty for the ECB's large scale asset purchases. In our model we therefore establish the bond market as the effective area of QE, before coming to the main upshot of our theoretical model: By acting as an additional supplier of money in the bond market, the central bank is able to lower the bond yields. This effect can be observed upon the mere announcement of QE and leads to decreasing credit risk and interest rate expectations, because agents on the bond market tend to price in actions of monetary policy as soon as they can be anticipated. Our second contribution is an empirical test of the hypotheses regarding the effect of QE derived from our model, on 5-year sovereign bond yields for Germany, France, Portugal, Spain, Italy and Ireland and the European benchmark bond. For this purpose, we apply an error correction model in section 5 in order to distinguish between long and short run effects on the bond market equilibrium of our model. In addition, we test the

[3] In terms of the banking sector, our model is similar to the model developed by Disyatat (2011).

hypotheses on credit risk and interest rate expectations via an event based regression. Our results are in line with our hypotheses based on the model. We find a negative yield effect on sovereign bond yields for most countries, but we also determine a yield increasing effect on German and French bond yields, which were not as severely affected by the Euro area crisis as the European periphery countries. We furthermore identify a clear-cut effect on credit risk, leading us to conclude that by conducting QE programs, the ECB rebuilt trust between financial actors and can therefore be seen as a "lender of confidence" causing the credit risk to decrease. Lastly, our findings regarding the effect of QE on interest rate expectations we acquired via the measurement of the effect on term premia reveal a diverse picture, speaking in favor of a portfolio rebalancing effect.

5.2 ECB monetary policy instruments

The four major central banks, namely Federal Reserve Bank (Fed), Bank of England (BoE), Bank of Japan (BoJ) and ECB, draw on a set of monetary policy tools to influence the economy. Under normal conditions they provide liquidity to the banking system by using standard instruments. Since the financial crisis, however, unconventional measures have been added to their toolboxes, to address the increased demand for liquidity in banking and bond market. When focusing on the ECB's instruments, we first categorize them by conventionality and targeted market before placing them in temporal context:[4]

1. Conventional Instruments
    a) Banking Market
        i. Main Refinancing Operations
        ii. Fine Tuning Reverse Operations
        iii. Structural Reverse Operations
        iv. Longer-Term Refinancing Operations

[4]The conventional instruments listed under item 1a comprise the operational framework of the Eurosystem, whereby the interaction of the ECB with the banking sector is limited to setting the price for short and longer-term refinancing of banks at the Central Bank. The unconventional measures taken by the ECB can be differentiated into liquidity support measures and quantitative easing, depending on the market in which the Central Bank takes action.

2. Unconventional Instruments

    a) Banking Market

        Liquidity Support Measures

        i. Longer-Term Refinancing Operations with a maturity > 3 months (LTRO)
        ii. Targeted Longer-Term Refinancing Operations (TLTRO)

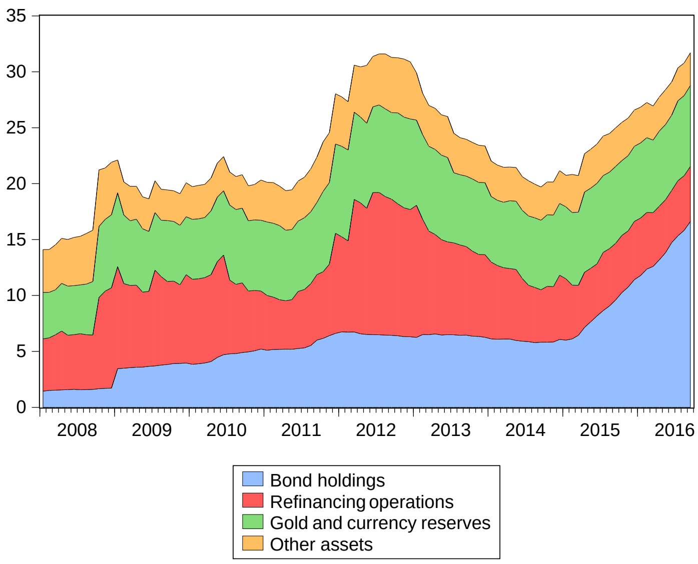
    b) Bond market

        Quantitative easing (QE)

        i. Covered Bonds Purchase Program (CBPP)
        ii. Securities Market Program (SMP)
        iii. Outright Monetary Transactions (OMT)
        iv. Public Sector Purchase Program (PSPP)
        v. Corporate Sector Purchase Program (CSPP)

Within a narrow time frame to the financial crisis spillover to Europe, shortly after the collapse of Lehman Brothers, the ECB attempted to counteract the loss of confidence among banks and the resulting dry up of interbank funding by employing conventional instruments, such as lowering the refinancing rate. In order to satisfy the increased demand for central bank refinancing, the ECB engaged in unconventional measures that extended its balance sheet significantly (see Figure 5.1). The composition of the Central Bank's

Figure 5.1: Composition of the ECB's assets in percent of GDP



Source: ECB and own calculations.

assets shows that the balance sheet expansion in the early years after the crisis is mainly accounted for by liquidity support measures. In particular, the ECB granted full allotment and extended the maturity of LTROs gradually from three months up to three years until the end of 2011, in order to close the funding gap in the banking sector, which had arisen as a result of the dysfunctioning interbank market. As these measures were insufficient by themselves to sustainably stabilize the interbank market, the ECB additionally introduced asset purchase programs. Especially, the employment of the so called Expanded Asset Purchase Programme, including a third CBPP, the PSPP and later the CSPP, caused another major expansion of central bank assets in 2015, right after the ECB's balance sheet had shrunk due to the repayment of excess liquidity between 2013 and 2014.

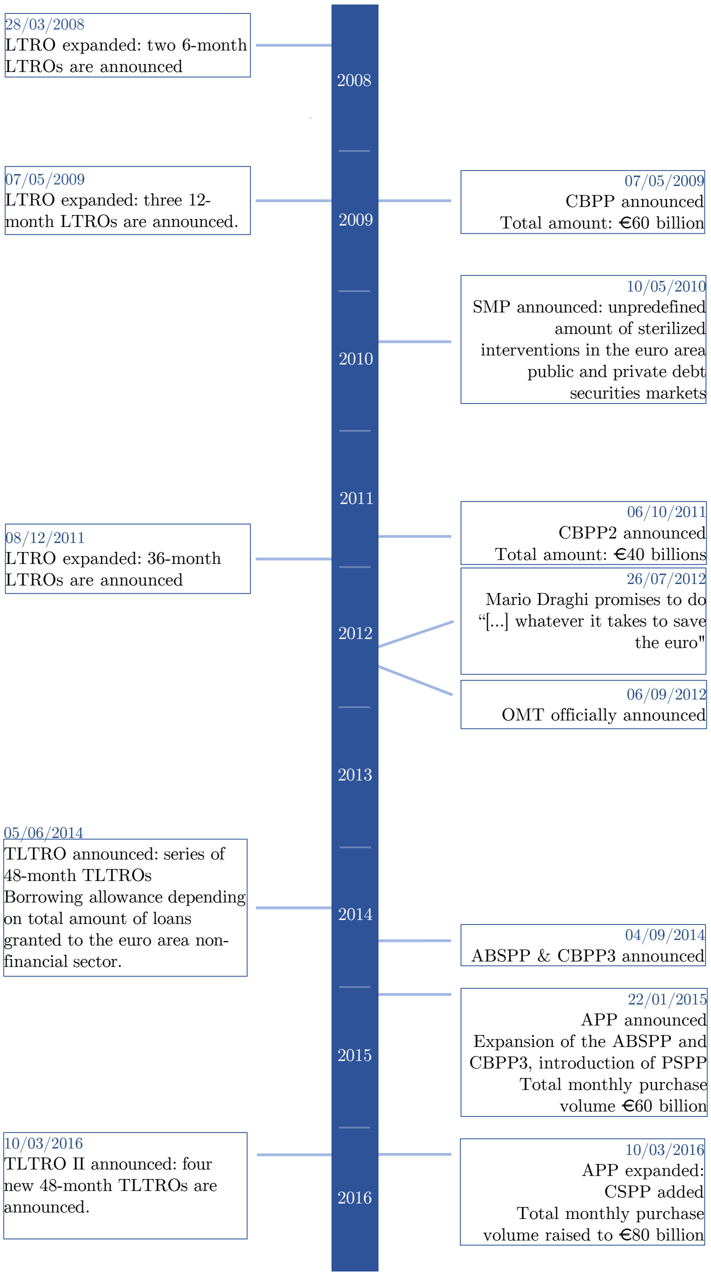
After the prolongation of two LTROs to a duration of six month on March 28, 2008, Jean-Claude Trichet offered three 12-month LTROs to provide even longer-term liquidity to banks and announced the ECB's first asset purchase program, the CBPP, on May 7, 2009. Backed by a dedicated pool of loans, Covered Bonds represent an important funding instrument of banks in the medium and long term. Accordingly, the ECB's motivation in purchasing Covered Bonds was firstly to ease the funding conditions of banks, and secondly to exert positive effects on funding conditions of non-financial corporations and households. Beyond the problems in the interbank market, the emergence of the sovereign debt crisis in Greece in 2010 induced an increase in default risk and fire sales of Eurozone government bonds. With the objective of preventing this development from getting out of hand and in order to "ensure the sustainability of [their] public finances" (see ECB, 2010), the ECB announced the SMP on May 10, 2010. Over the course of the SMP, the ECB conducted sterilized interventions in the public and private debt securities markets and purchased €219.5 billion in Euro area sovereign bonds, despite recurring criticism that it was overstepping its mandate. After the Greek debt crisis had somewhat stabilized in the beginning of 2011, concerns were raised about spillovers to Italy and Spain. This led Mario Draghi to affirm the ECB's subsequent willingness to continue the SMP in August 2011. Furthermore, the ECB reintroduced the CBPP on October 6, 2011, in response to the persistently stressed banking sector and the negative feedback loop of government bond yields on banks in the European periphery countries. To counteract the banks' ongoing fire sales of government bonds and to further stabilize the lending of the banking sector, on December 8, 2011, LTROs were extended to an exceptionally long period of 36 months in order to enable cheap long-term funding to combat the continual deleveraging of the banking sector. As concerns about the stability of the Eurozone increased due to the sovereign-banking nexus and the continuous accumulation of sovereign debt, Mario Draghi promised to do 'whatever it takes to save the euro' on July 26, 2012. This vague statement was interpreted by the markets as an unofficial announcement of another asset purchase program. The statement was substantiated when the Governing Council revealed the takeover of the SMP by the OMT on September 6, 2012, in order to smooth the monetary transmission and to harmonize credit conditions in the Eurozone. In contrast to the SMP, the OMT required governments to comply with the adjustment programs of the European Financial Stability Facility (EFSF) or the European Stability Mechanism (ESM), as a precondition to qualify for central bank purchases of sovereign bonds with a shorter maturity of between 1 and 3 years. A period of regeneration followed in 2013 and early 2014, before stress tests of the European Banking Authority again put pressure on European banks. In order to support the banking sector while encouraging its provision of credit to the private sector, in June 2014, the ECB extended the LTROs once more to a maturity of 48 months and set the borrowing allowance for banks contingent upon the total amount of loans granted to the Euro area non-financial sector (TLTROs). This recurrent easing of funding for banks was followed by the introduction of additional asset purchase programs. On September 4, 2014, the ECB introduced purchases of asset backed securities (ABSPP). As the underlying assets consist of claims against the non-financial private sector, the ABSPP was aimed at facilitating new credit flows to the non-financial sector. At the same time, the ECB announced another CBPP. Both the ABSPP and the CBPP3 were introduced without a predefined end date and are still ongoing with current holding volumes of €24 and €219 billion, respectively, as of May, 2017.

When the weak economic situation in the Eurozone was exacerbated further by low inflation rates and restrained inflation expectations, the ECB announced the addition of the PSPP to its current purchase programs in January 2015. Amounting to €60 billion, the monthly purchases of combined assets under the CBPP3, ABSPP, and PSPP were designed to counteract deflationary pressure and second-round deflationary effects on wages and prices.[5] Soon after the first purchases were made under the PSPP, the ECB expanded the total monthly purchase volumes and added investment-grade bonds of non-financial corporations to its portfolio on March, 10th 2016. Being the first ECB program to directly

[5]These programs were introduced at the zero lower bound in order to decrease directly long-term interest rates.

purchase corporate bonds, the aim of the CSPP is to bypass the weak banking sector and to strengthen the credit conditions for business financing directly. Ultimately, the ECB hopes to ease credit supply and exert an inflationary stimulus on the economy in the Eurozone via the asset purchase program as well as further conditional long-term liquidity provision to European banks (TLRTO II).

Figure 5.2: Timeline ECB unconventional policy



Note: The liquidity support measures taken by the ECB are listed in order on the lefthand side and the ECB's asset purchase programs are listed sequentially on the righthand side.

5.3 Literature Overview

In order to fully understand the empirical literature to which our paper belongs, the existing empirical literature on unconventional monetary policy must be considered in its entirety. The wealth of scientific research on unconventional monetary policy can be organized according to two main factors, namely the type of the program, i.e. either quantitative easing or liquidity support measures, and the central bank which implements the programs referred to in a paper. However, there are also a few papers which deal with the programs of two or more of the four major central banks.

Specifically, our paper belongs to the strand of literature focusing on the QE policy of the ECB, but is special in that it analyzes the macroeconomic effects on financial markets both theoretically and empirically. The empirical approach we employ to investigate the ECB's unconventional measures is related to those of Falagiarda and Reitz (2015), Szczerbowicz (2015), Gerlach-Kristen (2015), and Eser and Schwaab (2016), who analyzed the effects of QE on inter-country sovereign yield spreads in the Eurozone via event study. Moreover, our empirical study is closely related to those of Altavilla et al. (2015) and De Santis (2016), who performed event based regressions on sovereign bond yields, we however complement these works by evaluating the full range of unconventional instruments applied by the ECB up until late 2016.

5.3.1 Literature on Quantitative Easing

Due to a previous lack of data on and experience with QE as a form of unconventional monetary policy, the majority of the empirical literature on this topic has only evolved over the course of the last decade.[6] The announcement of the QE1 program by the Fed and the QE1 by the BoE, when both were in need of a monetary policy tool at the Zero Lower Bound during the post-crisis period, sparked the release of numerous papers on unconventional monetary policy instruments. Due to the lagged implementation of QE in the Eurozone, empirical studies on similar measures employed by the ECB were first conducted with some delay, and often follow highly-cited papers on Fed and BoE policies with regard to their structure and methodology. The empirical literature on QE can be

[6] One of the few acknowleged empirical papers on QE in the 20th century is a time series analysis by Modigliani and Sutch (1967) referring to the FED's "Operation Twist" in 1961. With the implementation of large scale asset purchases termed "quantitative easing" by the Bank of Japan shortly after the turn of the millennium, the number of empirical studies on QE started to grow, comprising papers by Bernanke et al. (2004), Okina and Shiratsuka (2004) and Ugai (2007).

classified by the observed part of the transmission mechanism. While one area of the empirical literature analyzes the effect of QE on macroeconomic aggregates, another area, that to which our paper belongs, focuses on the transmission of QE to financial markets.

Literature on Macroeconomic Transmission

In terms of measuring the effects of QE on the real economy, the most common methods applied are VAR models. Using a structural VAR model, Baumeister and Benati (2013) find that the interest rate spread shock implied by unconventional measures has a positive effect on output growth and that these measures were successful in preventing the danger of deflation in the US and the UK. Applying a Bayesian VAR model developed by Banbura et al. (2009), Lenza et al. (2010) get similar results for the Eurosystem and also identify a lag of several months in the positive real effects of QE. By implementing a panel VAR model, Gambacorta et al. (2014) find that for the US, the UK, and the Eurosystem an exogenous increase in the central bank's balance sheet effects output growth and inflation temporarily and non-persistantly at the Zero Lower Bound.

Empirical Literature on Financial Market Transmission

Event Studies For the analysis of effects on financial markets triggered by QE announcements, the most commonly chosen empirical approach is that of an event study aka. event based regression. This approach is based on the assumption that markets are forward looking and tend to price monetary policy actions in as soon as they can be anticipated. Therefore, event studies observe yield changes which occur around the time of an unconventional monetary policy announcement, integrated into the model as a dummy variable. Beyond proving the existence and identifying the magnitude of a decreasing effect on long-term yields, many event studies additionally try to disentangle and examine the distinct channels through which QE affects long-term yields and financial conditions. In accordance with term structure theory, the majority of these event studies identify the signaling and portfolio rebalancing channels.[7] Specifically, Joyce et al. (2011) and Bauer and Rudebusch

[7]Disregarding second-round effects of QE the signaling channel and portfolio balance channel explain the upward sloping yield curve. QE underpins future expectations of low short-term yields and thus lowers long-term yields via the signaling channel. In combination with the assumption of market segmentation, QE decreases the risk premium on the purchased assets, which again can be explained by a signaling effect imposed by the central bank's willingness to purchase an asset or by the lower market supply of bonds with a certain maturity resulting from the actual purchases. The latter explanation refers to the portfolio balance channel and also holds plausible for the spillover effects on substitute asset classes. In particular, investors tend to substitute bonds that are purchased by the central bank with bonds of a similar maturity

(2014) attribute changes in the Overnight Index Swap (OIS) rate to the signalling channel and changes in the UK gilt or the US treasury to OIS spreads to the portfolio rebalancing channel. In contrast, papers such as Krishnamurthy and Vissing-Jorgensen (2011) and D'Amico et al. (2012) uncover additional (sub-)channels through which QE affects financial markets, among others duration risk and safety premium channels.

Considering the respective central bank addressed by each event study, the most commonly cited event studies are conducted on the data of unconventional programs in the US, such as Gagnon et al. (2010), D'Amico et al. (2012), and Bauer and Rudebusch (2014). Other highly-cited papers comprise studies on the effects of the unconventional programs employed by the BoE, such as Joyce et al. (2011), and combined studies for both Fed and BoE programmes, as performed by Meaning and Zhu (2011). Less well-known event studies were performed on the QE programs of the BoJ by Bernanke et al. (2004) and Ueda (2012), and on those of the ECB. For the Eurozone, event studies identifying the impact of QE on long-term yields of asset classes purchased in the course of QE programs in the Eurozone were performed by Altavilla et al. (2015) and De Santis (2016), who both found a negative yield effect on asset classes purchased in the course of the APP. Additional to standard yield analyses, event based regressions may also measure the effectiveness of QE programs by observing inter-country yield spreads, taking German bonds as the risk free basis, are unique for the Eurozone. Such analyses include Falagiarda and Reitz (2015), Szczerbowicz (2015), and Eser and Schwaab (2016). While Eser and Schwaab (2016) found that the yield spread of periphery countries decreased significantly for the SMP, the former two proved this effect for both SMP and OMT.

While the main focus of most contributions to this area of research lies on the price and yield of a purchased domestic asset, there are papers which additionally analyze the spillover effect on other domestic asset classes as well. With regard to the ECB's programs, Szczerbowicz (2015) finds that the CBPP caused a spillover effect on sovereign bond spreads, and converseley, SMP and OMT produced a similar effect on covered bond yields. Furthermore, international spillovers to long-term sovereign bond yields are found for US and UK programs by Glick and Leduc (2012) and Neely (2015). However, the identified spillover effects are relatively small compared to the intended effects on targeted assets, when applying an event study approach, because of a weaker signaling channel for non-targeted assets.

and risk profile, e.g. corporate bonds or sovereign bonds issued by other countries, due to the existence of "preferred habitats" for investors (cf. Modigliani and Sutch, 1967; Vayanos and Vila, 2009).

Further econometric studies As event studies are primarily suited for identifying the significance of an initial yield drop around the announcement date of an asset purchase program, further econometric studies are often applied in some of the previously mentioned papers, in order to measure the long run impact of QE on bond rates. Generally, most econometric studies on QE find smaller yield effects than event studies, a result attributed to a strong initial announcement effect of purchase programs which then subsides over time, according to Martin and Milas (2012).
When used as an independent variable to explain changes in yields, QE can be included in the regression as either a stock or a flow variable. While Gagnon et al. (2010) and Joyce et al. (2011) base their estimates for yield changes on a stock variable, namely the volume of publicly held bonds, Meaning and Zhu (2011) regress the yield curve effects caused by QE on a flow variable, specifically the size of the regular asset purchases. As another distinctive feature to further structure econometric studies into two approaches, Martin and Milas (2012) refer to the periods of data used: Econometric models using the "historical data approach", as employed by Joyce et al. (2011) and Gagnon et al. (2010), assess the yield effect based on data from periods prior to the implementation of QE and additionally control for inflation and output movements, but only show the overall effect of various QE measures. In contrast to this, estimates using the "contemporary data approach", such as those conducted in this paper as well as that of Meaning and Zhu (2011), Glick and Leduc (2012), and D'Amico and King (2013) estimate the yield curve using daily or high-frequency data from the period in which QE programs took place. This practice allows the assessment of the effect of individual QE programs and considers the changed relationship between monetary policy and bond rates in times of financial distress.

5.3.2 Literature on Liquidity Support Measures

Literature on Liquidity Support Measures almost exclusively analyzes financial market effects, due to these measures being targeted at restoring the function of monetary transmission rather than at effecting inflation and growth directly (cf. Rieth and Gehrt, 2016). The estimation methods used to find evidence for the effectiveness of Liquidity Support Measures depend on the type and aims of the analyzed program, according to a survey by Borio and Zabai (2015). With regard to the central banks considered, the literature is limited to examination of programs by the ECB and the Fed, as the BoE did not introduce a special liquidity provision program for banks and the Stimulating Bank Lending Facility introduced by the BoJ in 2012 did not receive considerable attention. While the Fed eased refinancing conditions with the Term Auction Facility and the Term Securities Lending Facility, the programs of the ECB additionally extended the duration of long-term refinancing operations for the banking sector via LTROs and TLTROs. For the ECB's Liquidity Support Measures the literature consistently shows that additional liquidity provision achieved its goal. Using a time series regression on the implementation of LTROs at fixed rate tender with full allotment, Abbassi and Linzert (2012) find a sizeable reduction in Euribor rates of more than 100 bp, which can be explained by the increase in the aggregate amount of outstanding open market operations. Using a panel regression, Angelini et al. (2011) detect a significant spread reduction of 10 to 15 basis points between secured and unsecured interbank loans for the announcement of LTROs after the Lehman shock. In line with these results, the event based regression of Szczerbowicz (2015) states that the announcement and implementation of 3-year LTROs reduced Euribor-OIS spreads and consequently eased interbank lending significantly.

5.4 The Model

Recently, central banks have influenced the long-term interest rate on bonds by purchasing them in the bond market. In order to capture and depict the effects of QE theoretically, we therefore need a model which is capable of distinguishing the banking market from the bond market within the financial system.

In the banking market, banks are the suppliers of credit, while the borrowers represent the demand side. After credit provision, banks can choose between a mixture of central bank credit, deposits, equity and bonds to refinance their businesses. In this environment, the central bank is able to influence the banking sector's business by controlling the refinancing rate, making it a key determinant of banks' credit supply.

In the process of credit creation, banks create money, defined as the sum of cash and deposits, by making additional deposits. Money is differentiated from credit on its maturity. Money is a short-term concept on the liability side of the banking sector, whereas credit is recorded on the asset side of bank's balance sheet and refinanced with deposits, high-powered money, and longer-term refinancing sources, such as bonds and equity.

Money holders have the option of holding money either in liquid (cash and deposits) or illiquid (bonds) form. In buying bonds they implicitly provide money to counterparts who have a liquidity shortage.[8] Thus, when credit is granted in the bond market, money is merely changing hands.

In a financial system consisting of these two markets, borrowers have the option of demanding bank credit or demanding credit on the bond market. Beyond the interconnection of the two demand sides, the supply side of the banking market is linked to the bond market as well. Banks are able to refinance their businesses by issuing bonds in the bond market. Thus the cost of the banking sector depends on the interest rate for bonds.

The two most important insights of the model are the illustration of endogenous credit creation in the banking market (Palley, 1996; Disyatat, 2011; McLeay et al., 2014; Werner, 2014) and the development of the bond market where the created money is redistributed. The model is described as follows: We first derive the equilibrium interest rate and credit amount of the banking market. For refinancing purposes after granting credit, banks demand a fixed proportion of credit, determined by the credit multiplier relation, in high-powered money. In line with the equilibrium amount of credit, we derive the demand for high-powered money, which is abundantly met by the central bank. The equilibrium in the bond market is then derived similarly to the banking market equilibrium.

5.4.1 Banking Market

In order to derive the equilibrium for the banking market, we need to set up the respective supply and demand function. The market is in equilibrium when the supply of loans is equal to their demand.

Supply side Banks seek to maximize their profit. While for the banking and bond markets the revenue generated by granting credit depends on the interest rate spread between the interest rate for lending and that for borrowing (see for banks Spahn (2013); Friedman (2013, 2015)), the cost structure differs for the two markets, with the banking sector facing higher costs. The reasons for the higher costs of the banking sector are that banks face higher credit risk due to the higher risk profile of its borrowers, and lastly, specified capital requirements due to banks' higher risk profile. Keeping in mind that the profit function for one representative bank j is

$$\pi_B^j = i_B Cr_{B/NB}^j - i_D D^j - i_R(Cr_{CB/B}^j - R^j) - i_E E^j - i_{NB} B^j - O^j - V_B^j$$
$$\text{with } V_B^j = c_B (Cr_{B/NB}^j)^2,$$

[8] In the general literature, what we refer to as credit supply in the bond market is called bond demand.

the revenue is determined by credit granted to non-banks $Cr_{B/NB}$ at the price of credit i_B. The costs for the banking sector consist of the interest paid on deposits $i_D D$, on the net refinancing costs arising from central bank refinancing $i_R(Cr_{CB/B} - R)$, on equity refinancing $i_E E$, and on the funds borrowed from the bond market $i_{NB} B$, plus operational costs O and credit risk costs V_B, whereby it is assumed that the latter one will increase disproportionately with an increase in the credit volume (Fuhrmann, 1987).
Using the balance sheet identity according to the following balance sheet of a bank j (see Table 5.1), we can further derive $Cr^j_{CB/B} - R^j = Cr^j_{B/NB} - D^j - E^j - B^j$.

Table 5.1: Bank's balance sheet

Assets	Liabilites
Credit from Banks to Non-banks $Cr_{B/NB}$	Equity E
Reserves R	Bonds B
	Deposits D
	Credit from Central Bank to Banks $Cr_{CB/B}$

In addition, we assume that a fixed proportion of credit granted to the non-banking sector $\eta^E = \frac{E^j}{Cr^j_{B/NB}}$ is held as equity according to the Basel Regulatory framework, and another proportion $\eta^B = \frac{B^j}{Cr^j_{B/NB}}$ is held as bonds to reduce interest rate risk (according to the Liquidity Coverage Ratio and Net Stable Funding Ratio declared in Basel III). This leads us to the following profit function (5.1). By maximizing (5.1) with respect to credit volume and solving for $Cr^j_{B/NB}$, we receive the credit supply for a single bank j, which leads us to the credit supply for the banking sector (5.2) by summing up for n homogeneous banks

$$\pi^j_B = (i_B - i_R) - \eta^E(i_E - i_R) - \eta^B(i_{NB} - i_R))Cr^j_{B/NB} - (i_D - i_R)D^j - O^j - c_B(Cr^j_{B/NB})^2 \tag{5.1}$$

$$Cr^S_{B/NB} = n\sum_{j=1}^{n} Cr^j_{B/NB} = n\left(\frac{(i_B - i_R) - \eta^E(i_E - i_R) - \eta^B(i_{NB} - i_R)}{2c_B}\right) \tag{5.2}$$

Demand Side The demand for credit stems from borrowers (sovereigns, non-financial corporations, and households) that are usually driven by the desire to invest and/or consume (Minsky et al., 1993). Because of high entrance costs and the lack of opportunity to trade small volumes of credit on the bond market, the two types of credit (bank credit and bonds) represent imperfect substitutes and the cost of credit is different for each market. Consequently, apart from the economy's income, the determinants of credit demand are the spread between the interest rate for credit in the respective market and the credit interest rate in the substitution market.

The amount of credit demanded depends negatively on the respective price, where the saturation amount a is dependent on income. Furthermore, the demand for bank loans depends positively on the price for the substitute loan type, with the effect, dependent on the substitution elasticity d, ranging from values of 0 (fully independent loans) to ∞ (perfect substitutes).[9] This yields the following demand function for bank loans:

$$Cr_B^D = a - bi_B + d(i_{NB} - i_B),$$
$$\text{with } a = \mu + \gamma Y.$$

Equilibrium Assuming $n = 1$ and solving the equilibrium condition for the banking market, we get

$$Cr^*_{B/NB} = \frac{a - (b+d)(i_R + \eta^E(i_E - i_R) + \eta^B(i_{NB} - i_R)}{1 + 2c_B(b+d)}$$
$$i^*_B = \frac{2c_B(a + di_{NB}) + (i_R + \eta^E(i_E - i_R) + \eta^B(i_{NB} - i_R))}{1 + 2c_B(b+d)}.$$

Bank credit multiplier

In granting credit, banks simultaneously demand high-powered money in accordance with their liability structure. In order to derive the fraction of credit refinanced by high-powered money, we first need to define a bank credit multiplier m_B, which is the ratio of credit from banks to non-banks $Cr_{B/NB}$ to high-powered money H. As money consists of cash and deposits, high-powered money consists of cash and reserves, and $Cr_{B/NB}$ can be rewritten as $\frac{M}{1-\eta^E-\eta^B}$, thus the money multiplier can be redefined as follows:

$$m_B = \frac{Cr_{B/NB}}{H} = \left(\frac{1+h}{h+r}\right)\left(\frac{1}{1-\eta^E-\eta^B}\right),$$

where h represents the cash holding coefficients of the public and r the minimum reserve requirements , both of which are calculated as fractions of deposits.

Assuming $\eta^E + \eta^B < 1$, $h > 1$ and $r > 1$, the bank credit multiplier is always greater than one.

[9]The demand function with respect to the substitutability is derived by Singh and Vives (1984), Wied-Nebbeling (1997), and Ledvina and Sircar (2011).

Market for High-powered Money

The demand for high-powered money is determined by the volume of bank credit at a given refinancing rate. For the derivation of the linear high-powered money demand function, we need to obtain two points on the line. First, we use the equilibrium amount of credit granted ($Cr^*_{B/NB}$) to obtain the demanded volume of high-powered money (H^*) over the multiplier relation at the respective refinancing rate (i_{R_0}). Second, we determine the refinancing rate, at which the demand for high-powered money equals zero. By subtracting the spread for equity and bond refinancing from the prohibitive price of credit demand, we obtain this refinancing rate at which the volume of granted credit is equal to zero and consequently the demand for high-powered money is equal to zero as well. Analytically, the demand function for high-powered money is defined as:

$$H^D = e\frac{m_B}{Cr^*_{B/NB}}(e-1) - \frac{m_B}{Cr^*_{B/NB}}(e - i_{R_0})i_R$$
$$\text{with } e = (\frac{a + di_{NB}}{b+d}) - \eta^E(i_E - i_R) - \eta^B(i_{NB} - i_R).$$

As the central bank serves as a monopolistic supplier of high-powered money, it meets the full demand for high-powered money at the fixed price of the refinancing interest rate.

5.4.2 Bond Market

Once money is created in the process of bank lending, it can be used for buying bonds in the bond market.[10] The bond market functions similarly to the banking market. But in contrast to the banking market's role as the platform for money creation, the bond market is the platform for money circulation, where money is reused multiple times in order to create credit.

Supply side The revenues of the bond market suppliers are determined by the spread between the interest rate for long-term lending and the deposit rate because investors can only choose between either holding money as deposits or lending it. In contrast to the banking sector, non-banks do not face any cost due to capital requirements and their cost due to interest rate risk arise from opportunity costs of holding money as deposits.

[10] We assume that for the derivation of the bond market no additional funds from the banking market flow into the bond market.

Consequently, the profit function of a non-bank k appears as follows:

$$\pi_{NB}^k = i_{NB}Cr_{NB}^k - i_D Cr_{NB}^k + (\frac{i_{NB}}{i_{t+1}^e} - \frac{i_{NB}}{i_t})Cr_{NB}^k - I^k - V_{NB}^k,$$
$$\text{with } V_{NB}^k = c_{NB}(Cr_{NB}^k)^2.$$

The revenue is determined by the revenues of the credit business $i_{NB}Cr_{NB}^k$. The costs stemming from granting credit are opportunity costs $i_D Cr_{NB}^k$, and those from the possibility of bond price losses, the so called *term premium*, are depicted in the term $(\frac{i_{NB}}{i_{t+1}^e} - \frac{i_{NB}}{i_t})Cr_{NB}^k$, according to which an increase in the expected interest rate i_{t+1}^e results in losses on bonds. Furthermore, information cost I^k and credit risk costs V_{NB}^k add to the costs faced by non-banks.

For the purpose of simplicity, we assume that $i_D = i_R$ and bonds are priced at par, yielding to $i_{NB} = i_t$. After maximizing the resulting profit function (5.3) with respect to credit volume and solving for Cr_{NB}^k, we receive the credit supply for a single non-bank k, which we convert to the credit supply for the non-banking sector by summing it up for m homogeneous non-banks (5.4):

$$\pi_{NB}^k = (i_{NB} - i_D)Cr_{NB}^k + (\frac{i_{NB}}{i_{t+1}^e} - 1)Cr_{NB}^k - I^k - c_{NB}(Cr_{NB}^k)^2 \tag{5.3}$$

$$Cr_{NB}^S = m\sum_{k=1}^{m} Cr_{NB}^k = m\left(\frac{(i_{NB} - i_R) + (\frac{i_{NB}}{i_{t+1}^e} - 1)}{2c_{NB}}\right). \tag{5.4}$$

Demand Side Alongside sovereigns and non-financial corporations, banks are a major borrower in the bond market. Banks demand credit from the bond market in order to reduce the maturity mismatch in the balance sheet which results from their business model of lending long and borrowing short.

The determinants of credit demand in the bond market are the given economy's income, the cost of credit, and cost of credit of the substitute loan type, similar to those in the banking market. This yields the following demand function:

$$Cr_{NB}^D = a - bi_{NB} + d(i_B - i_{NB}),$$
$$\text{with } a = \mu + \gamma Y.$$

Equilibrium After equating credit demand with supply, we obtain the equilibrium amount of credit and interest rate in the bond market:

$$Cr^*_{NB} = \frac{(a + di_B)\left(\frac{i^e_{t+1}+1}{i^e_{t+1}}\right) - (b + d)(i_R + 1)}{\frac{i^e_{t+1}+1}{i^e_{t+1}} + 2c_{NB}(b + d)}, \tag{5.5}$$

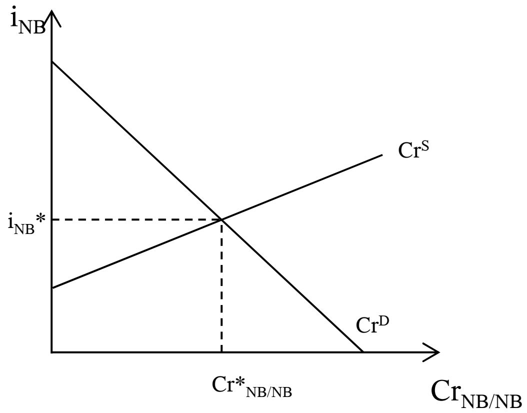
$$i^*_{NB} = \frac{2c_{NB}(a + di_B) + i_R + 1}{\frac{i^e_{t+1}+1}{i^e_{t+1}} + 2c_{NB}(b + d)}. \tag{5.6}$$

Comparing the equilibria in the banking and the bond market, we detect asymmetry with regard to interest rates and credit volumes, which is a result of differing costs on the supply sides. However, bank loans and bonds coexist in equilibrium due to institutional factors.[11]

5.4.3 Graphical illustration

We graphically derive the bond market (see Figure 5.3). In contrast to the intercept of the loan supply in the banking market, which is determined by the refinancing rate, the cost of equity, and the cost of bonds, here the intercept is set by the refinancing rate and the interest rate expectations in the bond market. At the intersection of the - in comparison with the banking market - similarly shaped demand curve and the flatter supply curve[12] lie the equilibrium amount of non-bank credit $Cr^*_{NB/NB}$ and the interest rate i^*_{NB} in the bond market.

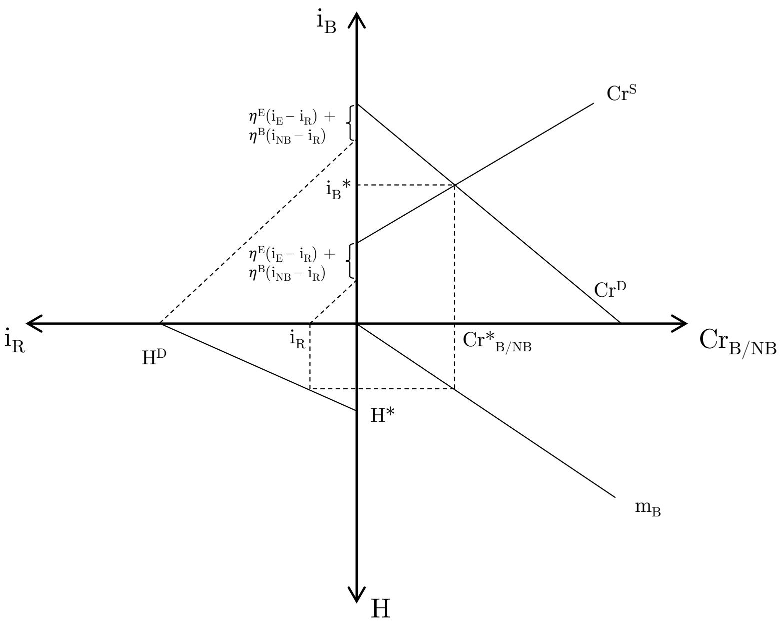
Figure 5.3: Bond market



[11]Banks' money creation is a prerequisite for the functioning of the bond market.
[12]Non-bank suppliers face lower costs than the banking sector.

Regarding the market for bank credit (see Figure 5.4), the equilibrium amount of credit $Cr^*_{B/NB}$ and the interest rate i^*_B lie at the intersection of the negatively sloped loan demand curve and the positively sloped loan supply curve. By inserting the equilibrium amount of bank credit into the bank credit multiplier relation m_B with a slope of > 1, we obtain the demanded amount of high-powered money H (second quadrant). This demand for high-powered money H can be displayed on the negatively sloped demand function for high-powered money at the price of i_R (third quadrant).

Figure 5.4: Bank credit market



5.4.4 Unconventional monetary policy

In the following, we apply the unconventional monetary policy instruments (Liquidity Support Measures and QE) described in Chapter 3 to our model.

Liquidity Support Measures target the liability side of the banking sector's balance sheet. The introduction of several unconventional long-term refinancing operations by the ECB is meant to address refinancing problems that have repeatedly emerged in the interbank market and the bond market since the financial crisis. In the context of our model, these measures offer the banking system an opportunity to ameliorate the maturity mismatch by refinancing with lower-yield central bank loans instead of high-yield bonds. As a result, the proportion of borrowing conducted by the banking sector in the bond market, η^B , declines. This inference regarding the composition of the aggregated balance sheet of the banking sector in the Euro area is taken into account.

In contrast to this, the ECB's **QE** targets the asset side of the balance sheets of bank and non-bank suppliers of financing. In our theoretical model, QE exhibits three effects, which we identify in the following hypotheses:

Hypothesis 1: Decline in bond yields

First, we expect a decline in bond yields due to the intervention of the ECB on the bond market. The ECB acts as additional supplier of liquidity who is able to shift the supply curve to the right which ceteris paribus leads to a decrease in bond yields. However, assuming forward looking agents on the bond market, these agents already take the announcements of QE into account. Therefore, the announcements of QE by the ECB influence the behavior of the supply side in our model, which leads to the second and third hypothesis.

Hypothesis 2 : Decrease in credit risk

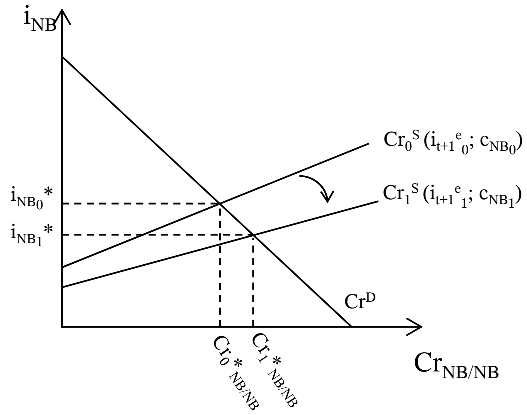
Since the quality of outstanding credit deteriorates in times of financial turmoil, the credit risk of these assets has increased. By acting as a lender of confidence, the ECB helps to *decrease the credit risk* of bonds issued by sovereigns (SMP, OMT and PSPP), banks (CBPP), and non-financial corporations (CSPP). This results in a decline in credit risk costs c_{NB}, which ceteris paribus implies a declining interest rate in the bond market i_{NB}. This effect is already obtained by the announcement of the ECB, because the agents on the bond market are forward looking such that they price this effect at the announcement day in.

Hypothesis 3: Decrease in interest rate expectations

Additionally, the central bank's interventions influence the *expectations on long-term interest rates*, but the overall effect on interest rate expectations is ambiguous. If bond market participants expect an ongoing decline in long-term interest rates due to further QE programs, expected interest rates will decline as well. Alternatively, bondholders may expect a rise in long-term bond rates due to the fact that the central bank is not able to lower the bond rates further, as the interest rate has reached the zero lower bound. Hence, we conclude that QE programs lower expected interest rates in the short run, but increase the expected interest rate in the long run, thus diminishing the initial effect of QE.

Graphically, the latter two effects of QE depict that the credit supply curve of the non-banking sector rotates clockwise due to reduced credit risk costs ($c_{NB_0} \rightarrow c_{NB_1}$), and shifts parallel downward due to lower interest rate expectations in the short run ($i^e_{t+1_0} \rightarrow i^e_{t+1_1}$), leading to a decrease in the equilibrium interest rate in the bond market ($i^*_{NB_0} \rightarrow i^*_{NB_1}$).[13]

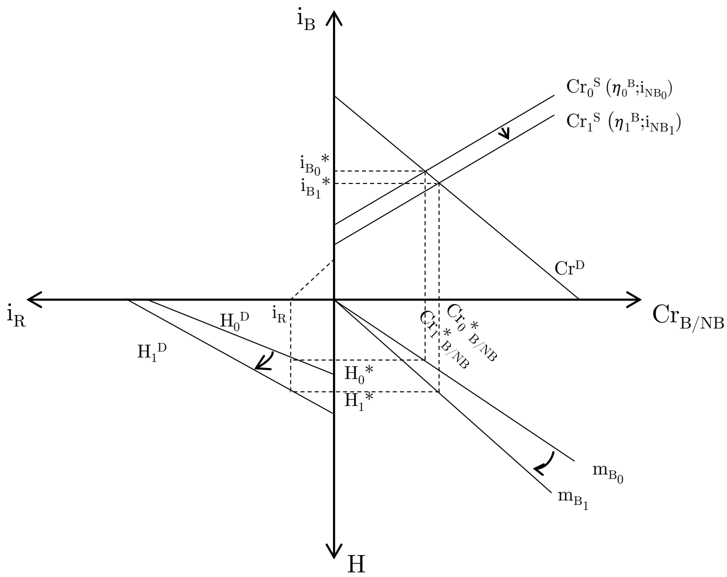
Figure 5.5: Unconventional monetary policy in the bond market



In the banking market, the lower interest rate on bonds ($i_{NB_0} \rightarrow i_{NB_1}$) and the reduction in the proportion of lending in the bond market ($\eta^B_0 \rightarrow \eta^B_1$) lead to a parallel downward shift in the credit supply curve of the banking sector. This results in a lower interest rate and an increase in credit volume in the banking market. Due to the shift in bank's financing structure away from refinancing in the bond market and towards refinancing through the central bank, the bank credit multiplier declines. In particular, the demand for high-powered money increases because the banking system demands the long-term refinancing operations, which substitute for funds from the bond market.

[13]We assume that at the new equilibrium $d(i_{B_0} - i_{NB_0}) = d(i_{B_1} - i_{NB_1})$ in order to abstract from demand side effects.

Figure 5.6: Unconventional monetary policy in the bank credit market



5.5 Empirical Evidence

In the empirical section, we test the hypotheses derived in section 5.4.4 regarding the effects of QE on the bond market, and on the sovereign bond market in particular.[14] First, we test the hypothesis that the announcements of QE lead to a decline in bond yields (hypothesis 1), and second, we show that the yield-depressing effect of QE operates via two transmission channels, reducing both credit risk (hypothesis 2) and interest rate expectations (hypothesis 3). To test the hypothesis regarding bond yields, we use an error correction model, which provides the advantage of addressing both the long and the short run effects of our theoretical model. In a second step, we apply an event-based regression to isolate the effects of QE on credit risk and interest rate expectations.

A possible issue of empirical evaluations in the context of quantitative easing is that announcements of QE become endogenous as soon as the ECB reacts to market developments such as e.g. a rise in credit spreads. We deal with this issue by following Fratzscher et al. (2012) in assuming that the QE announcements were of the 'leaning-against-the-wind' variety.

[14]We do not consider the effects in the banking market which arose via liquidity support measures due to the non-availability of daily banking data.

5.5.1 Error Correction Model

The methodology of an error correction model was first applied by Sargan (1964) in the context of wage and price adjustments in the UK. Particularly within the framework of financial markets, many authors have estimated the long run money demand equation or interest rate adjustments using an error correction model (Mehra, 1993; Heffernan, 1997; Winker, 1999; Dreger and Wolters, 2015).

In the previous chapter, we derived the long run equilibrium for the bond market (see Equations 5.5 and 5.6). When estimating this equilibrium in levels, we face the problem of spurious regression results due to non-stationary time series (see Appendix, Tables 2-6). In order to solve this problem, we apply an error correction model. The error correction model assumes that a long run equilibrium relationship exists, but that in the short run we observe disturbances which lead to a divergence from the equilibrium.

Based on this distinction between long and short run effects, we now present the two parts of the error correction model (Sargan, 1964; Davidson et al., 1978).

First, we identify the long run relationship which is explained by our theoretical model. Using daily data for our estimation and excluding bank interest rates, due to their non-availability on a daily basis, we define

$$i_{NB_t} = \alpha_0 + \alpha_1 i_{R_t} + \alpha_2 log(Y_t) + \alpha_3 c_{NB_t} + \alpha_4 i_t^e + u_t, \tag{5.7}$$

consisting of the sovereign bond yield i_{NB_t}; the refinancing rate of banks i_{R_t}; the log of income in the current period $log(Y_t)$; the credit risk costs c_{NB_t}; the interest rate expectations for bonds of the same maturity as the respective government bond i_t^e; and the error term of the long run model u_t. All variables are specified as levels at time t except for income, which is indicated in log-levels.

Second, the short run relationship consists of all variables of the long run model in first differences. Accordingly, we obtain the following equation:

$$\begin{aligned}\Delta i_{NB_t} = \beta_0 + \beta_1 \sum_{n=0}^{N_1} \Delta i_{R_{t-n}} + \beta_2 \sum_{n=0}^{N_2} \Delta log(Y_{t-n}) + \beta_3 \sum_{n=0}^{N_3} \Delta c_{NB_{t-n}} \\ + \beta_4 \sum_{n=0}^{N_4} \Delta i_{t-n}^e + \beta_5 \sum_{n=0}^{N_5} \Delta i_{NB_{t-n}} + \beta_6 u_{t-1} + \epsilon_t.\end{aligned} \tag{5.8}$$

For the short run equation the variables are similar to those of the long run equation, but are defined in first differences with current and past lags for $N_i = \{1, 2, 3, ...\}$. u_{t-1} is the lagged disturbance term of the long run equation and ϵ_t is the short run error term. The coefficient of u_{t-1}, β_6 is the adjustment term of the short run equation. It states that the interest rate of government bonds deviating from the equilibrium converges towards it. For the validity of the error correction model to be maintained, the interest rate of government bonds must not diverge from the long run equilibrium, requiring u_t in the long run equation to be stationary and the coefficient of u_{t-1} in the short run equation to be negatively significant.

There are two possible ways to estimate the error correction model. The first is to estimate Equation 5.7 and plug the obtained error term into Equation 8, while the second procedure is to substitute the long run equation for u_{t-1} in the short run equation (Stock, 1987). Using the latter method, we obtain

$$\begin{aligned}\Delta i_{NB_t} = \theta_0 + \beta_1 \sum_{n=0}^{N_1} \Delta i_{R_t-n} + \beta_2 \sum_{n=0}^{N_2} \Delta log(Y_{t-n}) \\ + \beta_3 \sum_{n=0}^{N_3} \Delta c_{NB_{t-n}} + \beta_4 \sum_{n=0}^{N_4} \Delta i^e_{t-n} + \beta_5 \sum_{n=0}^{N_5} \Delta i_{NB_{t-n}} \\ + \theta_1 i_{NB_{t-1}} + \theta_2 i_{R_{t-1}} + \theta_3 log(Y_{t-1}) + \theta_4 c_{NB_{t-1}} + \theta_5 i^e_{t-1} + \epsilon_t,\end{aligned} \tag{5.9}$$

where the coefficients are defined as follows:

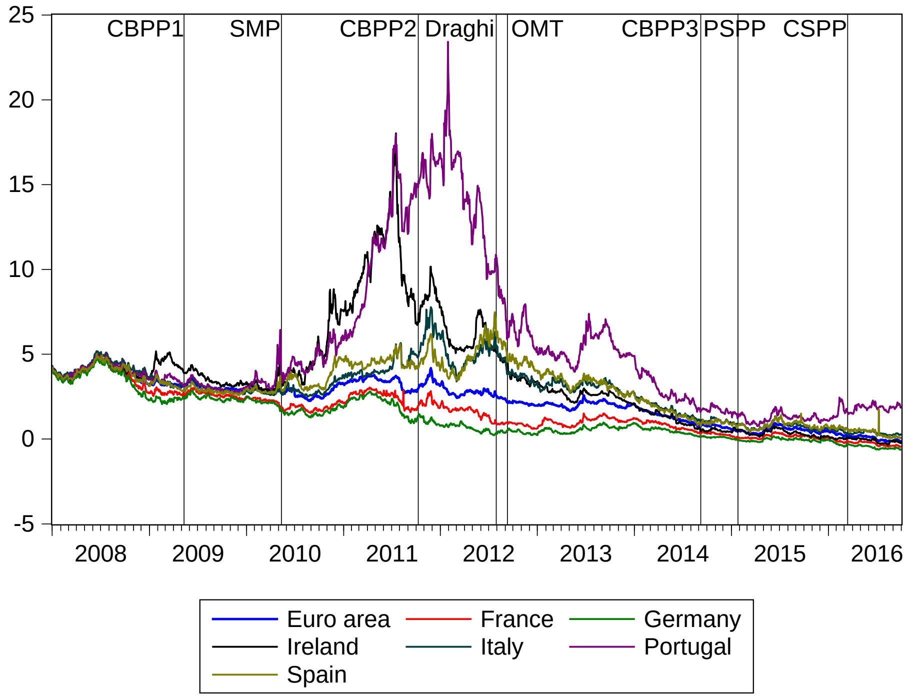
$$\begin{aligned}\theta_0 &= \beta_0 - \beta_6\alpha_0; \\ \theta_1 &= \beta_6; \\ \theta_2 &= -\beta_6\alpha_1; \\ \theta_3 &= -\beta_6\alpha_2; \\ \theta_4 &= -\beta_6\alpha_3; \\ \theta_5 &= -\beta_6\alpha_4.\end{aligned}$$

The short run coefficients (β_1 to β_5) can be drawn directly from Equation 5.9. To obtain the long run effects (θ_1 to θ_5), in Equation 5.7 we recalculate the short run effects from Equation 5.9. For instance, to obtain the coefficient of the refinancing rate i_{R_t}, we divide θ_2 by $-\theta_1$, which is equal to $-\beta_6$.

Data

We use daily data from January 1st, 2008 through September 30th, 2016 in order to evaluate the effect of QE on 5-year sovereign bond yields of France, Germany, Ireland, Italy, Portugal, Spain, and the Euro area. We choose a maturity of five years due to the focus of the ECB's purchases on bonds of this maturity.

Figure 5.7: Sovereign bond yields



Our dependent variable is the **sovereign bond yield** with a maturity of 5 years. The sovereign bond rates for each country are shown in Figure 5.7. Over the entire time horizon, the sovereign bond yields for Germany and France stayed the lowest, which underlines their status as a safe haven for investors in the Euro area. Furthermore, the yield on the Euro area benchmark bond graphically separates the countries which suffered from the sovereign debt crisis (Italy, Ireland, Portugal, and Spain) from the safe haven countries (Germany and France). Prior to the financial crisis the sovereign bond yields for all euro area countries coincided, except for small deviations which occurred in early 2009. Since the start of the euro area crisis in 2010, however, the sovereign bond rates of Spain, Portugal, Ireland, and Italy have begun to increase and to diverge from the government bond rates of France and Germany. Particularly Ireland and Portugal, which have been financially supported by the European rescue programs, experienced very high interest rates from 2010 until the end of 2012. Since the end of 2012 the interest rates have declined and have reached in

2014 lower levels than before the euro area crisis. Additionally, Figure 5.7 also displays the announcement days of the ECB's QE programs. Evidently, the programs tailored to the sovereign bond market, i.e. SMP, Draghi's speech[15], OMT and PSPP, effected a decline in sovereign bond yields. The PSPP in particular contributed to the convergence of sovereign bond yields, whereas programs for banks (CBPP1-3) and non-financial corporations (CSPP) seem to have had no direct effect on interest rates of sovereign bonds.

As previously implied by our estimating equation, a key determinant for sovereign bond yield is the short-term refinancing rate. We use the **EONIA** as the short-term refinancing rate in the Euro area (see Fig. 5.8 (a)). In reaction to the bankruptcy of Lehman Brothers and the triggered spillover effect on banks in the Euro area, the ECB soon began to cut refinancing rates. In 2011, however, it increased the refinancing rate, which in turn led to an increase in government bond yields. With the dawn of the euro area crisis, characterized by a highly indebted fiscal sector, the ECB started to lower the refinancing rate until it reached negative levels in 2016. This had a direct impact on German sovereign bond yields, which closely follow the short-term refinancing rate.

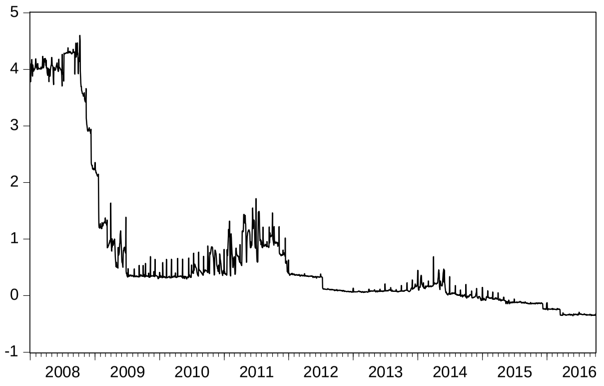
A quite similar development to that of sovereign bond yields can be observed for **credit risk spreads** (see Fig. 5.8 (b)). As measures of credit risk we use CDS spreads for each country and the bond spread for the Euro area benchmark bond[16] due to the non-availability of CDS spreads for the Euro area benchmark bond. CDS spreads are the price for credit insurance, and therefore show the perceived default risk for each borrower. The SMP, Draghi's speech and the OMT had a strong reducing effect on the CDS spreads of Ireland, Italy, Spain, and Portugal (see also Gerlach-Kristen, 2015). Since Draghi's speech, CDS spreads have decreased for all observed euro area countries.

[15]Draghi's speech can be seen as an implicit announcement of new QE programs initiated by the ECB.

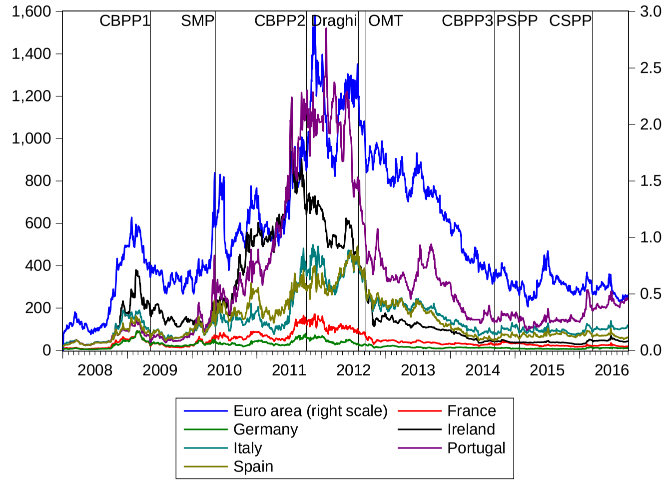
[16]Calculated as the difference between the yield on the Euro area benchmark bond and the German sovereign bond yield.

Figure 5.8: Independent variables

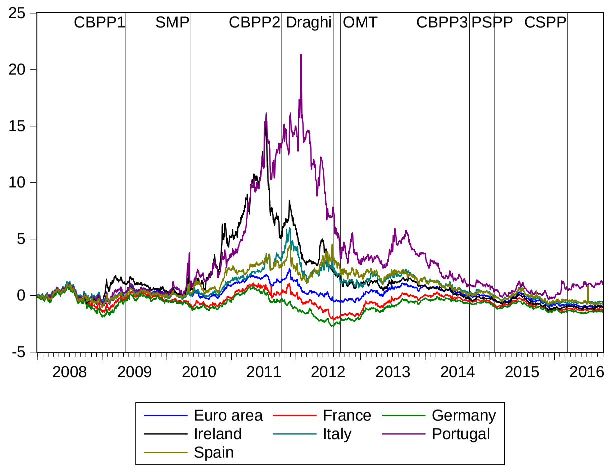
(a) EONIA in percent



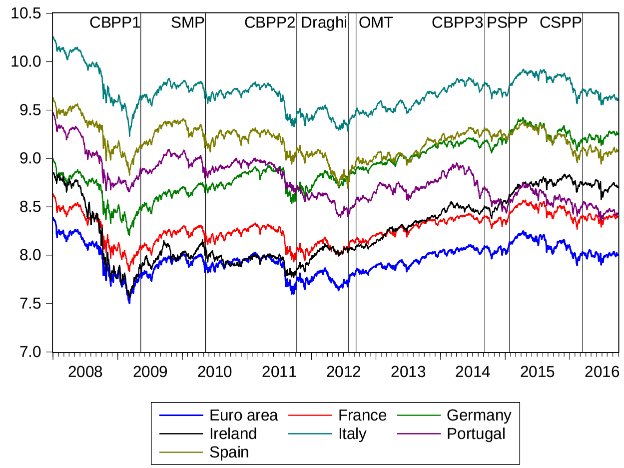
(b) Credit risk spread



(c) Term premium



(d) Equity indexes



In order to capture the effect of **interest rate expectations**, and thereby of expected capital losses on long-term bonds, we compute the risk/term premium for each country.[17] During the financial crisis investors have perceived the risk of capital losses as high (see Fig. 5.8 (c)). For Germany and France we even observe negative term premia. This indicates that investors prefer fixed interest over the entire investment horizon to fluctuating interest rates of shorter-term investments. As for the credit risk spreads, since Draghi's speech the term premium for each of the observed countries has converged to its pre-crisis level.
We use equity indexes as a proxy for income due to their availability on a daily basis. At the beginning of 2009, after the burst of the housing bubble, the **equity markets** were at their lowest levels during the observed period (see Fig. 5.8 (d)). In comparison with the other European equity markets depicted, the German and Portuguese equity indexes have exhibited better performance since 2009. Since the announcement of the PSPP, every observed index has increased.

Unit roots and Cointegration

In order to analyze each time series for the presence of unit roots, we use the augmented Dickey-Fuller test, the Phillips-Perron test, and the KPSS test.[18] For almost every time series the results indicate non-stationarity, with the exception of the equity indexes, for which the augmented Dickey-Fuller and the Phillips-Perron tests suggest stationarity but the KPSS test indicates non-stationarity. Consequently, we assume that each equity index has a unit root for our long run model.
When we regress a non-stationary variable on other non-stationary variables, cointegration of these variables should lead to stationary results. If this holds true, the linear combination of the variables is stationary as well. In order to test this assumption, we apply the Johansen cointegration method. For each country, the test results of the trace and maximum eigenvalue tests reveal at least one cointegrated equation at the 5 % significance level.

[17]Since risk averse lenders want to be compensated for the risk of capital losses throughout their holding period (Gürkaynak and Wright, 2012), they demand term premia. These are calculated as the difference between the current bond rate with a maturity of 5 years and the mean of the EONIA forward rates of 1,2,3,4, and 5 years.

[18]for test results, see Appendix, Tables 2-6.

Regression setup

Building on the preliminary tests, we estimate Equation 5.9 by error correction model methodology.

To capture the effects of QE, we implement dummy variables for the announcement days of QE.

We assume that spillover effects on sovereign bond yields occur for the programs which are targeted toward banks and non-financial corporations as well. Thus we control for the announcements of CBPP 1-3 and the CSPP.

In accordance with Gerlach-Kristen (2015), we additionally control for the effects from bail-outs for Greece (May 5, 2010 and July 22, 2011), Portugal (May 16,2011), and Ireland (November 22, 2010) and from the default of Greece (February 21, 2012).

By including all relevant ECB purchase programs as dummy variables as well as the control variables in Equation 5.9, we receive the following equation:

$$
\begin{aligned}
\Delta i_{NB_t} = {} & \theta_0 + \theta_1 i_{NB_{t-1}} + \theta_2 i_{R_{t-1}} + \theta_3 log(Y_{t-1}) + \theta_4 c_{NB_{t-1}} + \theta_5 i^e_{t-1} \\
& + \beta_1 \sum_{n=0}^{N_1} \Delta i_{R_t-n} + \beta_2 \sum_{n=0}^{N_2} \Delta log(Y_{t-n}) + \beta_3 \sum_{n=0}^{N_3} \Delta c_{NB_{t-n}} \\
& + \beta_4 \sum_{n=0}^{N_4} \Delta i^e_{t-n} + \beta_5 \sum_{n=0}^{N_5} \Delta i_{NB_{t-n}} \\
& + \beta_6 \text{CBPP} + \beta_7 \text{OMT} + \beta_8 \text{SMP} + \beta_9 \text{PSPP} + \beta_{10} \text{CSPP} + \beta_{11} \text{Draghi's speech} \\
& + \beta_{12} \text{Greece} + \beta_{13} \text{GreeceDefault} + \beta_{14} \text{Portugal} + \beta_{15} \text{Ireland} + \epsilon_t.
\end{aligned}
\tag{5.10}
$$

Regression results

We estimate our model for the full sample (see Table 5.8) and for three subsamples (see Tables 5.9, 5.10, and 5.11). The need for three subsamples, one sample each for before, during, and after the crisis, arises due to multiple breakpoint tests revealing that there are structural breakpoints in the time series around the days at the beginning (April 22, 2010) and end (August 1, 2012) of the crisis.

The results show that for the full sample the error correction model delivers significant results with a negative sign for the lagged independent variable, with the exception of Germany and the Euro area, where the results are non-significant. The error correction model is also appropriate for the subsamples of France, Ireland, Spain, and the Euro area. For all other countries we observe at least one subsample that indicates that the error correction model is inappropriate.

For the full sample, the long run coefficients (lagged credit risk spread, lagged EONIA, lagged equity, and lagged term premium) for the euro area, France, Italy, Spain, and Portugal show the expected positive sign, but only some coefficients are significant. Interestingly, we find a significant negative effect of the EONIA on bond yields during the crisis, again with the exception of Germany and the Euro area. This effect indicates the fact that the control of the ECB were reduced due to the predominance of other factors (as e.g. uncertainty) during this period. The sign of the term premium indicates its significant positive influence on bond yields for most of the subsamples and for the full sample.

We are mainly interested in the effect of QE announcements on sovereign bond yields. When analyzing spillover effects on sovereign bond yields for the CBPP1 and CBPP2, we find an increase in bond rates for each country. This spillover effect on sovereign bonds, although they are not purchased directly, can be explained by portfolio substitution effects away from sovereign bonds towards bank bonds, or by increasing concerns about government rescue programs for banks. For the CBPP3 we detect the opposite effect, which can be attributed to a backward shift to sovereign bonds due to a healthier banking sector.

For the CSPP announcement, a significant negative sign can be observed for Germany, Spain, Portugal, Italy, Ireland, and the Euro area. As for the CBPP1, the CBPP2, and the CBPP3, the effect on sovereign bond yields stemming from the CSPP, which was designed to buy corporate bonds only, is merely an indirect effect occurring via asset substitution.

The QE programs targeting the sovereign bond market present a different profile. On the announcement days of the SMP and the OMT the bond yields for Germany and France increased. A plausible explanation for this result is that the ECB only acted as a lender of confidence for the countries most heavily affected by the euro area crisis. Another interpretation of the result is that lenders, who sold the bonds of periphery countries to the ECB, repurchased German and French bonds in the bond market. Both explanations are in line with the ECB's intentions of the the SMP and OMT to smooth the monetary transmission channel and to achieve a convergence of the sovereign bond yields in the euro area. The surprising rise in the 5-year bond yields of Spain, Italy, and Ireland with the announcement of the OMT can be explained by the fact that this program was designed to purchase bonds with a shorter maturity, ranging between 1 and 3 years. Furthermore, Draghi's speech had a negative significant effect on the bond yields of Germany, France, Italy, Portugal and the Euro area. After reaching the zero lower bound in 2012, the PSPP in 2014 was initiated in order to decrease long-term interest rates directly. The PSPP achieved this significant negative effect on the bond yields for each country.

5.5.2 Event Based Regression

After capturing the total effect of QE on sovereign bond yields, we examine the two channels via which QE operates according to our theoretical model - credit risk and term premium channel.

As already stated in section 4.4, the credit risk of sovereign bond yields decreased with the ECB acting as a lender of confidence. Furthermore, the ECB's purchase programs affected the expectations of sovereign bond investors, reflected in a reduced term premium.

We perform an event based regression in order to capture the effect of these programs on the CDS spreads and the term premium (Szczerbowicz, 2015; Falagiarda and Reitz, 2015).

Regression setup

We apply a standard linear regression and estimate it using OLS with Newey-West standard errors, regressing the change in CDS spreads on its lagged change, the announcement day dummies for QE, and control variables:

$$\begin{aligned}\Delta \text{CDS}_t = &\ \alpha + \beta_1 \Delta \text{CDS}_{t-1} + \beta_2 \text{CBPP} + \beta_3 \text{OMT} + \beta_4 \text{SMP} + \beta_5 \text{PSPP} + \beta_6 \text{CSPP} \\ &+ \beta_7 \text{Draghi's speech} + \beta_8 \text{EFSM/ESM} + \beta_9 \text{zero lower bound} \\ &+ \beta_{10} \Delta \text{VStoxx}_t + \beta_{11} \Delta \text{TED}_t + \beta_{12} \Delta \text{EuroStoxx50}_t + \epsilon_t.\end{aligned}$$

We control for financial turmoil using the volatility stock index VStoxx and for market-wide business climate changes with a stock market index for the EU (Euro Stoxx 50) as well as with information on credit risk in the global economy drawn from the TED spread (see Falagiarda and Reitz, 2015). Additionally, we control for dates of news releases on the European rescue programs EFSM and ESM, and for the dates on which the ECB reached the zero lower bound (see Szczerbowicz, 2015).

Taking the same approach as that employed for CDS spreads, we estimate the effects of QE on the term premium (tp):

$$\begin{aligned}\Delta \text{tp}_t = &\ \alpha + \beta_1 \Delta \text{tp}_{t-1} + \beta_2 \text{CBPP} + \beta_3 \text{OMT} + \beta_4 \text{SMP} + \beta_5 \text{PSPP} + \beta_6 \text{CSPP} \\ &+ \beta_7 \text{Draghi's speech} + \beta_8 \text{EFSM/ESM} + \beta_9 \text{zero lower bound} \\ &+ \beta_{10} \Delta \text{VStoxx}_t + \beta_{11} \Delta \text{TED}_t + \beta_{12} \Delta \text{EuroStoxx50}_t + \epsilon_t.\end{aligned}$$

Regression results

With regard to CDS spreads (see Table 5.12), it is apparent that QE has lowered the CDS spreads of the entire sample via CBPP1 and CBPP3. The SMP, OMT, Draghi's speech and CSPP were especially effective in reducing the CDS spreads of the countries that were most severly hit by the euro crisis (Spain, Portugal, Italy, and Ireland). The results for the SMP and OMT correspond to the results of Szczerbowicz (2015), who analyzes the spread of Eurozone sovereign bonds compared to that of German sovereign bonds. Nevertheless, we find also a negative significant effect of Draghi's speech on CDS spreads of Germany and France. An increase in CDS spreads was triggered by the CBPP2 for Spain, Portugal, Italy, Ireland, and France, and by the PSPP for Ireland, Germany, and France.

Concerning the term premia, for the SMP we detect the expected decrease triggered by QE (see Table 5.13) for Spain, Portugal, Ireland, Germany, and the Euro area. For the OMT we observe a significant negative effect on Spain, Portugal, and Italy, whereas we identify a significant positive effect for Ireland, Germany, and France. Draghi's speech contributed to a decline in term premium for each country with the exception of Germany. With respect to the PSPP, we estimate a significant negative impact on the term premia of Portugal, and Italy. In contrast, with the introduction of the PSPP the term premium for France turned positive. The results for the CSPP indicate a positive impact on term premia for Portugal, Spain, Ireland, Germany, and France, whereas for Italy a negative effect was observed.

In summary, we primarily observe a decrease in CDS spreads as a result of the QE programs. Their effects on term premia across the Euro area are not as distinct, which can be explained by the fact that the effect of QE on term premia likely diminished over the course of each of the announcement days, and we cannot capture the effect without intraday data.

5.6 Conclusion

In this paper we present a theoretical model, which is applicable to evaluate the effects of QE and its mere announcement on the financial system, before we derive and test hypotheses from this model on the effect of QE on sovereign bonds yields and their transmission channels.

The proposed model consists of a bank credit market and a bond market. In the bank credit market, banks supply credit to non-bank debtors and in this way create money.

Once money is created, non-banks holding money redistribute the money created by the banking sector by purchasing bonds, and in doing so implicitly granting loans to banks and non-banks. While our model is capable of depicting how central banks are able to influence both markets via the refinancing rate in conventional times, the introduction of the bond market into our model furthermore allows us to describe the effects of quantitative easing and its announcement. By purchasing bonds in the bond market, central banks are able exert a further expansionary stimulus. Therefore, the first hypothesis we derive from our model is that the central bank achieves a reduction of long-term bond yields by acting as an additional supplier on the bond market. Second, one transmission channel of QE on bond yields is the reduction of credit risk, and third, another transmission channel is the reduction interest rate expectations. To prove the first hypothesis empirically, we test the announcement effects of QE on 5-year sovereign bond yields, by applying an error correction model. We identify significant negative effects on the sovereign bond yields of periphery countries (Spain, Portugal, Ireland, and Italy) for the SMP, while we detect decreasing bond yields for each observed country for the PSPP. For the OMT the yield effects show the opposite sign, in terms of increasing bond yields on announcement days, across-the-board, with Portugal as the sole exception. To consider the two transmission channels through which QE effects long-term yields, we apply an event based regression. By that means we find a decrease in credit risk for most asset purchase program announcements, leading us to the conclusion that by carrying out QE, the ECB acts as lender of confidence. Using the same methodology to analyze the impact of QE on interest expectations, as expected we are not able to identify a clear-cut effect on term premia, neither for the individual programs nor for the respective countries. In total, the empirical assessment supports the results of our model and legitimates its use for the understanding of the effects of QE on bond market interest rates and sovereign bond yields in particular.

Further research might successfully be directed at theoretically and empirically analyzing the transmission channels and the effects our model implies on the interest rate for bank credit, caused by a decrease of the interest rate on the non-banking market. That is, a decrease in bank credit interest rates caused by lower bond market interest rates, which we have shown to be an effect of QE in this paper. In addition, further extensions of the model could include an equity market to endogenously determine the interest rate on equity, which again determines the bank credit interest rate as a key factor of the banks' credit supply.

5.7 Appendix to chapter 5

Table 5.2: Data sources

Variable	Source
Sovereign bond yields	Datastream
CDS spreads	Datastream
Equity Index	Datastream
EONIA	Datastream
VSTOXX	Datastream
TED spread	Datastream
forward rates	Bloomberg

Table 5.3: Unit root tests for EONIA

Variable	Test	P-val.		Test-stat.	Critical-val.: 5%	Decision
EONIA	ADF (w. Trend)	0.443				not stat.
	ADF (wo. Trend)	0.052				not stat.
	Phillips-Perron (w. Trend)	0.395				not stat.
	Phillips-Perron (wo. Trend)	0.111				not stat.
	KPSS (w. Trend)			0.643	0.146	not stat.
	KPSS (wo. Trend)			3.155	0.463	not stat.

ADF = Augmented Dickey Fuller test.
KPSS = Kwiatkowski-Phillips-Schmidt-Shin test.
w.= with; wo.=without.

Table 5.4: Unit root tests for sovereign bond yields of each country

Country	Test	P-val.		Test-stat.	Critical-val.: 5%	Decision
Spain	ADF (w. Trend)	0.758				not stat.
	ADF (wo. Trend)	0.836				not stat.
	Phillips-Perron (w. Trend)	0.690				not stat.
	Phillips-Perron (wo. Trend)	0.787				not stat.
	KPSS (w. Trend)			1.055	0.146	not stat.
	KPSS (wo. Trend)			3.202	0.463	not stat.
France	ADF (w. Trend)	0.080				not stat.
	ADF (wo. Trend)	0.606				not stat.
	Phillips-Perron (w. Trend)	0.070				not stat.
	Phillips-Perron (wo. Trend)	0.572				not stat.
	KPSS (w. Trend)			0.187	0.146	not stat.
	KPSS (wo. Trend)			5.249	0.463	not stat.
Germany	ADF (w. Trend)	0.191				not stat.
	ADF (wo. Trend)	0.368				not stat.
	Phillips-Perron (w. Trend)	0.253				not stat.
	Phillips-Perron (wo. Trend)	0.387				not stat.
	KPSS (w. Trend)			0.479	0.146	not stat.
	KPSS (wo. Trend)			5.100	0.463	not stat.
Ireland	ADF (w. Trend)	0.488				not stat.
	ADF (wo. Trend)	0.525				not stat.
	Phillips-Perron (w. Trend)	0.630				not stat.
	Phillips-Perron (wo. Trend)	0.634				not stat.
	KPSS (w. Trend)			0.807	0.146	not stat.
	KPSS (wo. Trend)			2.582	0.463	not stat.
Italy	ADF (w. Trend)	0.663				not stat.
	ADF (wo. Trend)	0.766				not stat.
	Phillips-Perron (wi. Trend)	0.600				not stat.
	Phillips-Perron (wo. Trend)	0.718				not stat.
	KPSS (w. Trend)			0.919	0.146	not stat.
	KPSS (wo. Trend)			3.366	0.463	not stat.
Portugal	ADF (w. Trend)	0.789				not stat.
	ADF (wo. Trend)	0.580				not stat.
	Phillips-Perron (w. Trend)	0.822				not stat.
	Phillips-Perron (wo. Trend)	0.620				not stat.
	KPSS (w. Trend)			0.914	0.146	not stat.
	KPSS (wo. Trend)			1.255	0.463	not stat.
Euro area	ADF (w. Trend)	0.273				not stat.
	ADF (wo. Trend)	0.877				not stat.
	Phillips-Perron (w. Trend)	0.297				not stat.
	Phillips-Perron (wo. Trend)	0.859				not stat.
	KPSS (w. Trend)			0.644	0.146	not stat.
	KPSS (wo. Trend)			5.154	0.463	not stat.

ADF = Augmented Dickey Fuller test.
KPSS = Kwiatkowski-Phillips-Schmidt-Shin test.
w.= with; wo.=without.

Table 5.5: Unit root tests for credit risk spreads of each country

Country	Test	P-val.		Test-stat.	Critical-val.: 5%	Decision
Spain	ADF (w. Trend)	0.658				not stat.
	ADF (wo. Trend)	0.332				not stat.
	Phillips-Perron (w. Trend)	0.665				not stat.
	Phillips-Perron (wo. Trend)	0.365				not stat.
	KPSS (w. Trend)			1.121	0.146	not stat.
	KPSS (wo. Trend)			1.145	0.463	not stat.
France	ADF (w. Trend)	0.493				not stat.
	ADF (wo. Trend)	0.269				not stat.
	Phillips-Perron (w. Trend)	0.431				not stat.
	Phillips-Perron (wo. Trend)	0.218				not stat.
	KPSS (w. Trend)			0.861	0.146	not stat.
	KPSS (wo. Trend)			1.021	0.463	not stat.
Germany	ADF (w. Trend)	0.094				not stat.
	ADF (wo. Trend)	0.102				not stat.
	Phillips-Perron (w. Trend)	0.102				not stat.
	Phillips-Perron (wo. Trend)	0.113				not stat.
	KPSS (w. Trend)			0.506	0.146	not stat.
	KPSS (wo. Trend)			0.810	0.463	not stat.
Ireland	ADF (w. Trend)	0.512				not stat.
	ADF (wo. Trend)	0.522				not stat.
	Phillips-Perron (w. Trend)	0.617				not stat.
	Phillips-Perron (wo. Trend)	0.598				not stat.
	KPSS (w. Trend)			0.776	0.146	not stat.
	KPSS (wo. Trend)			2.149	0.463	not stat.
Italy	ADF (w. Trend)	0.508				not stat.
	ADF (wo. Trend)	0.207				not stat.
	Phillips-Perron (w. Trend)	0.573				not stat.
	Phillips-Perron (wo. Trend)	0.249				not stat.
	KPSS (w. Trend)			0.923	0.146	not stat.
	KPSS (wo. Trend)			0.927	0.463	not stat.
Portugal	ADF (w. Trend)	0.795				not stat.
	ADF (wo. Trend)	0.471				not stat.
	Phillips-Perron (w. Trend)	0.777				not stat.
	Phillips-Perron (wo. Trend)	0.448				not stat.
	KPSS (w. Trend)			0.948	0.146	not stat.
	KPSS (wo. Trend)			0.945	0.463	not stat.
Euro area	ADF (w. Trend)	0.498				not stat.
	ADF (wo. Trend)	0.199				not stat.
	Phillips-Perron (w. Trend)	0.674				not stat.
	Phillips-Perron (wo. Trend)	0.332				not stat.
	KPSS (w. Trend)			1.180	0.146	not stat.
	KPSS (wo. Trend)			1.182	0.463	not stat.

ADF = Augmented Dickey Fuller test.
KPSS = Kwiatkowski-Phillips-Schmidt-Shin test.
w.= with; wo.=without.

Table 5.6: Unit root tests for term premium for each country

Country	Test	P-val.		Test-stat.	Critical-val.: 5%	Decision
Spain	ADF (w. Trend)	0.723				not stat.
	ADF (wo. Trend)	0.440				not stat.
	Phillips-Perron (w. Trend)	0.679				not stat.
	Phillips-Perron (wo. Trend)	0.387				not stat.
	KPSS (w. Trend)			1.232	0.146	not stat.
	KPSS (wo. Trend)			1.253	0.463	not stat.
France	ADF (w. Trend)	0.245				not stat.
	ADF (wo. Trend)	0.140				not stat.
	Phillips-Perron (w. Trend)	0.204				not stat.
	Phillips-Perron (wo. Trend)	0.092				not stat.
	KPSS (w. Trend)			0.152	0.146	not stat.
	KPSS (wo. Trend)			0.910	0.463	not stat.
Germany	ADF (w. Trend)	0.412				not stat.
	ADF (wo. Trend)	0.203				not stat.
	Phillips-Perron (w. Trend)	0.400				not stat.
	Phillips-Perron (wo. Trend)	0.196				not stat.
	KPSS (w. Trend)			0.199	0.146	not stat.
	KPSS (wo. Trend)			0.827	0.463	not stat.
Ireland	ADF (w. Trend)	0.535				not stat.
	ADF (wo. Trend)	0.346				not stat.
	Phillips-Perron (w. Trend)	0.644				not stat.
	Phillips-Perron (wo. Trend)	0.449				not stat.
	KPSS (w. Trend)			0.819	0.146	not stat.
	KPSS (wo. Trend)			1.252	0.463	not stat.
Italy	ADF (w. Trend)	0.662				not stat.
	ADF (wo. Trend)	0.390				not stat.
	Phillips-Perron (w. Trend)	0.614				not stat.
	Phillips-Perron (wo. Trend)	0.341				not stat.
	KPSS (w. Trend)			1.022	0.146	not stat.
	KPSS (wo. Trend)			1.069	0.463	not stat.
Portugal	ADF (w. Trend)	0.865				not stat.
	ADF (wo. Trend)	0.474				not stat.
	Phillips-Perron (w. Trend)	0.816				not stat.
	Phillips-Perron (wo. Trend)	0.517				not stat.
	KPSS (w. Trend)			0.940	0.146	not stat.
	KPSS (wo. Trend)			0.943	0.463	not stat.
Euro area	ADF (w. Trend)	0.452				not stat.
	ADF (wo. Trend)	0.333				not stat.
	Phillips-Perron (w. Trend)	0.408				not stat.
	Phillips-Perron (wo. Trend)	0.294				not stat.
	KPSS (w. Trend)			0.649	0.146	not stat.
	KPSS (wo. Trend)			1.180	0.463	not stat.

ADF = Augmented Dickey Fuller test.
KPSS = Kwiatkowski-Phillips-Schmidt-Shin test.
w.= with; wo.=without.

Table 5.7: Unit root test for logarithm of equity indexes of each country

Country	Test	P-val.		Test-stat.	Critical-val.: 5%	Decision
Spain	ADF (w. Trend)	0.092				not stat.
	ADF (wo. Trend)	0.017				stat.
	Phillips-Perron (w. Trend)	0.141				not stat.
	Phillips-Perron (wo. Trend)	0.028				stat.
	KPSS (w. Trend)			0.531	0.146	not stat.
	KPSS (wo. Trend)			0,.876	0.463	not stat.
France	ADF (w. Trend)	0.016				stat.
	ADF (wo. Trend)	0.041				stat.
	Phillips-Perron (w. Trend)	0.022				stat.
	Phillips-Perron (wo. Trend)	0.056				not stat.
	KPSS (w. Trend)			0.578	0.146	not stat.
	KPSS (wo. Trend)			1.817	0.463	not stat.
Germany	ADF (w. Trend)	0.009				stat.
	ADF (wo. Trend)	0.747				not stat.
	Phillips-Perron (w. Trend)	0.010				stat.
	Phillips-Perron (wo. Trend)	0.778				not stat.
	KPSS (w. Trend)			0.323	0.146	not stat.
	KPSS (wo. Trend)			4.835	0,463	not stat.
Ireland	ADF (w.Trend)	0.041				stat.
	ADF (wo. Trend)	0.565				not stat.
	Phillips-Perron (w. Trend)	0.033				stat.
	Phillips-Perron (wo. Trend)	0.588				not stat.
	KPSS (w. Trend)			0.858	0146	not stat.
	KPSS (wo. Trend)			3.008	0.463	not stat.
Italy	ADF (w. Trend)	0.105				not stat.
	ADF (wo. Trend)	0.018				stat.
	Phillips-Perron (w. Trend)	0.102				not stat.
	Phillips-Perron (wo. Trend)	0.017				stat.
	KPSS (w. Trend)			0.727	0.146	not stat.
	KPSS (wo. Trend)			0.761	0.463	not stat.
Portugal	ADF (w. Trend)	0.057				not stat.
	ADF (wo. Trend)	0.046				stat.
	Phillips-Perron (w. Trend)	0.063				not stat.
	Phillips-Perron (wo. Trend)	0.044				stat.
	KPSS (w. Trend)			0.247	0.146	not stat.
	KPSS (wo. Trend)			3.379	0.463	not stat.
Euro area	ADF (w. Trend)	0.021				stat.
	ADF (wo. Trend)	0.013				stat.
	Phillips-Perron (w. Trend)	0.029				stat.
	Phillips-Perron (wo. Trend)	0.020				stat.
	KPSS (w. Trend)			0.590	0.146	not stat.
	KPSS (wo. Trend)			1.048	0.463	not stat.

ADF = Augmented Dickey Fuller test.
KPSS = Kwiatkowski-Phillips-Schmidt-Shin test.
w.= with; wo.=without.

Table 5.8: Regressions for ECM- Full sample

	France	Germany	Ireland	Italy	Portugal	Spain	Euro area
Constant	-0.042	0.055	0.082	-0.150	-0.077	-0.225***	-0.081
Lagged variables							
Bond yield, $(i_{NB_{t-1}})$	-0.003*	-0.004	-0.005**	-0.002*	-0.005***	-0.005***	-0.001
Credit risk spread [1], $c_{NB_{t-1}}$	3.62E-05	-4.18E-05	1.24E-05	2.43E-05	1.62E-05	8.17E-05***	0.002
EONIA, $i_{R_{t-1}}$	0.002	0.002	-0.001	0.001	0.003**	0.003**	0.001
log(Equity index), $log(Y_{t-1})$	0.005	-0.006	-0.009	0.015	0.009	0.024***	0.010
Term premium, i^e_{t-1}	0.003*	0.003	0.004**	0.003*	0.004***	0.002	0.001
First differences							
ΔCredit risk spread [1], Δc_{NB_t}	0.001	-0.002***	0.001***	0.001***	2.40E-04***	0.001***	0.342***
ΔEONIA, Δi_{R_t}	-0.013	-0.003	-0.017	-0.015	-0.018*	-0.017*	-0.006
Δlog(Equity index), $\Delta log(Y_t)$	0.262***	0.602***	-0.066	-0.035	-0.086	0.023***	0.550***
ΔTerm premium, Δi^e_t	0.660***	0.491***	0.919***	0.763***	0.950***	0.859***	0.461
QE announcements							
CBPP1	0.111***	0.058***	0.008**	0.032***	0.017***	0.022***	0.064***
CBPP2	0.053***	0.020***	0.043***	0.025***	0.030***	0.027***	0.041***
CBPP3	-0.051***	-0.049***	-0.030***	-0.038***	-0.028***	-0.029***	-0.056***
SMP	0.029***	0.035***	-0.069***	-0.009	-0.008	-0.046***	-0.059***
Draghi speech	-0.032***	-0.005**	-0.006	-0.106***	0.002	-0.005	-0.046***
OMT	0.005*	0.029***	0.011***	0.013	-0.015***	0.026***	0.010***
PSPP	-0.025***	-0.029***	-0.020***	-0.027***	-0.017***	-0.015***	-0.036***
CSPP	-0.015	0.030***	-0.066***	-0.048***	-0.074***	-0.070***	0.021***
Sovereign bail-out and default announcements							
Portugal	0.013***	0.005***	0.024***	0.002	-0.004	0.011***	0.007***
Ireland	-0.015***	-0.020***	-0.013***	-0.018***	-0.013***	-0.008***	-0.019***
Greece	-0.016***	-0.014	0.010	0.011***	0.001	-0.016	-0.015***
Greece Default	0.032***	0.029***	0.039***	0.016***	0.052***	0.015***	0.021***
Adjusted R^2	0.684	0.611	0.944	0.849	0.972	0.890	0.635
Number of observations	2283	2283	2082	2283	2253	2275	2283

Dependent variable: Δbond yield, i_{NB_t}.

[1] Credit risk spread for individual countries are measured by CDS spreads and for euro area benchmark bond by bond spread to 5-year Germany sovereign bond.

Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Two-tailed test.

Table 5.9: Regressions for ECM- pre-crisis

	France	Germany	Ireland	Italy	Portugal	Spain	Euro area
Constant	0.322	-0.034	0.338	0.417	0.496**	-0.050	0.106
Lagged variables							
Bond yield, $(i_{NB_{t-1}})$	-0.076***	-0.060***	-0.050***	-0.071***	-0.073***	-0.066***	-0.064***
Credit risk spread [1], $c_{NB_{t-1}}$	2.36E-05	1.09E-04	2.09E-04**	1.02E-04	2.58E-04***	2.37E-04**	0.022
EONIA, $i_{R_{t-1}}$	0.028***	0.021***	0.014**	0.029***	0.025***	0.025***	0.020***
log(Equity index), $log(Y_{t-1})$	-0.017	0.020	-0.028	-0.025	-0.035	0.022	0.007
Term premium, i^e_{t-1}	0.033***	0.028**	0.020**	0.033***	0.035***	0.022*	0.021**
First differences							
ΔCredit risk spread [1], Δc_{NB_t}	-0.001	-0.002*	0.001***	0.001**	0.001***	-3.43E-04	0.119
ΔEONIA, Δi_{R_t}	-0.020	-0.001	-0.026	-0.020	-0.009	-0.024	-0.008
Δlog(Equity index), $\Delta log(Y_t)$	0.349****	0.598***	0.041	0.097	0.337**	0.047	0.545***
ΔTerm premium, Δi^e_t	0.503***	0.457***	0.624***	0.543***	0.551***	0.412***	0.461***
QE announcements							
CBPP1	0.141***	0.067***	0.014**	0.037***	0.017***	0.028***	0.060***
Adjusted R^2	0.633	0.626	0.713	0.606	0.650	0.670	0.564
Number of observations	418	418	400	418	418	418	418

Dependent variable: Δbond yield, i_{NB_t}.

[1] Credit risk spread for individual countries are measured by CDS spreads and for euro area benchmark bond by bond spread to 5-year Germany sovereign bond.

Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Two-tailed test.

Table 5.10: Regressions for ECM- during the crisis

	France	Germany	Ireland	Italy	Portugal	Spain	Euro area
Constant	-0.180	-0.140	-0.307	0.062	0.481**	0.020	-0.440**
Lagged variables							
bond yield, ($i_{NB_{t-1}}$)	-0.040***	-0.010	-0.023***	-0.011	-0.021**	-0.012*	-0.017**
Credit risk spread [1], $c_{NB_{t-1}}$	-3.92E-05	-5.03E-05	-5.10E-06	5.67E-08	-3.37E-05	2.88E-05	0.012**
EONIA, $i_{R_{t-1}}$	-0.014*	-0.003	-0.014*	-0.017**	-0.019***	-0.017**	-0.002
log(Equity index), $log(Y_{t-1})$	0.034	0.018	0.047*	-0.003	-0.046*	0.001	0.060**
Term premium, i^e_{t-1}	0.024***	0.005	0.022***	0.012*	0.022***	0.012*	0.007
First differences							
ΔCredit risk spread [1], Δc_{NB_t}	1.41E-04	-0.001**	0.001	3.8E-04**	7.98E-05	3.51E-04**	0.357***
ΔEONIA, Δi_{R_t}	-0.024**	-0.010	-0.021*	-0.026**	-0.029**	-0.026**	-0.011
Δlog(Equity index), $\Delta log(Y_t)$	0.264**	0.828***	0.092	0.067	0.120	0.068	0.804***
ΔTerm premium, Δi^e_t	0.847***	0.566***	0.976***	0.913***	0.982***	0.919***	0.514***
QE announcements							
CBPP2	0.037***	0.020***	0.041***	0.032***	0.036***	0.030***	0.034***
SMP	-0.001	0.019***	-0.031***	-0.017	-0.021	-0.036***	-0.057***
Draghi speech	-0.026***	-0.020***	-0.006	-0.053***	-0.018***	-0.021***	-0.048***
Sovereign bail-out and default announcements							
Portugal	0.009**	0.006**	0.007	0.005	0.002	0.012***	0.009***
Ireland	-0.007**	-0.017***	4.42E-04	-0.005*	4.53E-04	-0.001	-0.015***
Greece	-0.004	-0.011	0.005	0.009	0.005	-0.005	-0.012***
Greece Default	0.034***	0.027***	0.036***	0.030***	0.044***	0.026***	0.020***
Adjusted R^2	0.847	0.728	0.985	0.944	0.993	0.944	0.795
Number of observations	595	595	595	595	595	595	595

Dependent variable: Δbond yield, i_{NB_t}.

[1] Credit risk spread for individual countries are measured by CDS spreads and for euro area benchmark bond by bond spread to 5-year Germany sovereign bond.

Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Two-tailed test.

Table 5.11: Regressions for ECM- post-crisis

	France	Germany	Ireland	Italy	Portugal	Spain	Euro area
Constant	-0.002	0.105	0.070	-0.063	0.128	0.003	-0.153*
Lagged variables							
bond yield, $(i_{NB_{t-1}})$	-0.005*	-0.009**	-0.010***	-0.007*	-0.007	-0.017***	-0.018**
Credit risk spread [1], $c_{NB_{t-1}}$	6.25E-05	-1.86E-04	7.36E-06	4.26E-05	-1.72E-05	1.28E-04**	0.025***
EONIA, $i_{R_{t-1}}$	0.005	0.013	-0.016*	-0.003	0.002	0.006	0.007
log(Equity index), $log(Y_{t-1})$	3.29E-04	-0.011	-0.007	0.007	-0.014	4.31E-04	0.019*
Term premium, i^e_{t-1}	0.002*	0.002	0.012***	0.007**	0.008**	0.013***	0.007***
First differences							
ΔCredit risk spread [1], Δc_{NB_t}	2.40E-04	-0.001	0.001*	0.003***	0.001**	0.001	0.396***
ΔEONIA, Δi_{R_t}	-0.010	-0.017	-0.022	-0.009	-0.020	-0.033	-0.022
Δlog(Equity index), $\Delta log(Y_t)$	0.020*	0.242***	-0.236***	-0.234**	-0.248**	-0.052	0.0915
ΔTerm premium, Δi^e_t	0.435***	0.376***	0.651***	0.614***	0.882***	0.886***	0.358***
QE announcements							
CBPP3	-0.059***	-0.048***	-0.034***	-0.038***	-0.027***	-0.025***	-0.050***
OMT	0.015***	0.048***	0.021***	0.048***	-0.035***	0.038*	0.032***
PSPP	-0.023***	-0.025***	-0.023***	-0.027***	-0.018***	-0.014***	-0.030***
CSPP	-0.018***	0.042***	-0.029***	-0.025***	-0.071***	-0.072***	0.029***
Adjusted R^2	0.442	0.394	0.688	0.791	0.934	0.904	0.528
Number of observations	1087	1087	1087	1087	1087	1087	1087

Dependent variable: Δbond yield, i_{NB_t}.

[1] Credit risk spread for individual countries are measured by CDS spreads and for euro area benchmark bond by bond spread to 5-year Germany sovereign bond.

Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Two-tailed test.

Table 5.12: Event based regression for credit risk spreads

	France	Germany	Ireland	Italy	Portugal	Spain	Euro area
Constant	0.002	0.004	0.043	0.063	0.116	0.046	3.08E-04
ΔCredit risk spread [1], $\Delta c_{NB_{t-1}}$	0.477***	0.477***	0.477*	0.442***	0.465***	0.441***	0.442***
QE announcements							
CBPP1	-3.513***	-4.090***	-10.898***	-7.542***	-8.485***	-6.727***	-0.054***
CBPP2	2.168***	-3.555***	6.429***	5.316***	33.109***	4.540***	-0.036***
CBPP3	0.220	0.188***	1.003**	-0.545	-3.300***	-1.020***	0.006***
SMP	0.446	-0.662	-14.647**	-8.447	-70.503***	-8.376	-0.091***
Draghi speech	-0.892***	-0.856***	-4.325***	-7.259***	-8.521***	-7.959***	-0.040***
OMT	-1.787***	-0.117	-14.006***	-34.630***	-13.403***	-38.343***	-0.068***
PSPP	0.930***	0.919***	1.981***	-2.140***	-4.887***	0.023	-0.005***
CSPP	-0.893***	-0.121**	-2.187***	-6.318***	-3.174***	-5.300***	-0.041***
Control variables							
EFSM/ESM	-0.630	0.201	-7.412	-10.102*	-12.482***	-12.366**	-0.049
Zero lower bound	3.911***	-0.872***	-5.459***	7.629***	16.486***	9.394***	0.016***
ΔVSTOXX$_t$	0.096	0.064*	-0.013	0.132	0.347	0.219	0.001*
ΔTED$_t$	0.001	0.003	0.143**	-3.19E-05	0.008	-0.010	1.69E-05
ΔEuroStoxx$_t$	-0.007***	-0.003**	-0.033***	-0.036***	-0.100***	-0.030***	-1.08E-04***
Adjusted R^2	0.528	0.560	0.469	0.572	0.522	0.577	0.541
Number of observations	2281	2281	2080	2281	2251	2281	2281

Dependent variable: ΔCredit risk spread [1], Δc_{NB_t}.

[1] Credit risk spread for individual countries are measured by CDS spreads and for euro area benchmark bond by bond spread to 5-year Germany sovereign bond.

Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Two-tailed test.

Table 5.13: Event based regression for term premia

	France	Germany	Ireland	Italy	Portugal	Spain	Euro area
Constant	-0.001	-0.001	9.35E-05	4.57E-05	0.001	-2.28E-04	-2.38E-04
ΔTerm premium, Δi^e_{t-1}	0.492***	0.468***	0.491***	0.489***	0.495***	0.494***	0.494***
QE announcements							
CBPP1	0.221***	0.128***	0.033***	0.032***	0.030***	0.102***	0.075***
CBPP2	0.058***	0.073***	0.021***	-0.034***	0.147***	0.035***	0.036***
CBPP3	-0.017***	-0.023***	-0.008	-0.022***	-0.004	0.032***	-0.015***
SMP	0.003	-0.054***	-0.346**	0.014	-0.299*	-0.143*	-0.127***
Draghi speech	-0.046***	0.005	-0.124***	-0.113***	-0.027**	-0.003*	-0.022***
OMT	0.042***	0.062***	0.044***	-0.196***	-0.524***	-0.134***	-0.005
PSPP	0.003	-0.008	-4.67E-04	-0.033***	-0.030***	-0.003	-0.011***
CSPP	0.041***	0.073***	0.037***	-0.010**	0.016***	0.089**	0.027***
Control variables							
EFSM/ESM	-0.005	-0.007	-0.187	-0.122	-0.136	-0.094	-0.037
Zero lower bound	-0.158***	-0.088***	-0.055***	-0.041***	-0.147***	0.151***	-0.083***
ΔVSTOXX$_t$	-0.003*	-0.001	0.002	0.002	0.005	-0.001	6.61E-04
ΔTED$_t$	3.23E-04	2.63E-04	0.001	1.67E-04	0.001	1.25E-04	2.83E-04
ΔEuroStoxx$_t$	3.09E-05	2.26E-04***	6.29E-05	-8.95E-05	1.17E-04	-6.61E-05	1.19E-04***
Adjusted R^2	0.520	0.540	0.483	0.528	0.483	0.497	0.504
Number of observations	2281	2281	2281	2281	2281	2281	2281

Dependent variable: ΔTerm Premium, Δi^e_t.
Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Two-tailed test.

Chapter 6

Conclusion

This dissertation provided a detailed discussion of the main issues concerning the financial system in a monetary economy. I now review the main concepts of the theoretical model and offer suggestions for future research regarding the monetary paradigm.

In a first step, I argued that the LFT is an inappropriate framework for the financial system in a monetary economy. Given the inadequacy of the LFT, I developed an alternative model for the financial system in a monetary economy, consisting of a bank credit market and a bond market. In this model, both the banking sector and money play integral roles. Specifically, money is used as a means of financing in the economy. Money is created in the bank credit market and redistributed in the bond market, where credit is created. The motive of the supply side in the bank credit market is similar to that of the supply side in the bond market. However, the banking sector faces higher costs stemming from regulatory requirements as well as higher credit risk costs than do the suppliers of liquid funds in the bond market. Specifically, the central bank is able to control credit creation in both markets via the refinancing rate. For banks, the price of high-powered money (refinancing rate) is the primary factor in determining the price of credit. Suppliers in the bond market decide to either hold their funds as deposits (liquid) or to grant credit (illiquid). This decision is influenced by the price for deposits, which is assumed to be approximately equal to the refinancing rate at the central bank. Furthermore, the two markets are interconnected via both the supply and the demand sides. Regulators require that banks decrease their maturity mismatch via refinancing in the bond market. Consumers of credit have the option to demand credit in either the bank credit market or the bond market. Thus, demand shifts between the two markets. It is worth mentioning that multiple credit creation is possible in both markets.

This model is able to capture the effects of unconventional monetary policy, as it addresses the fact that central banks intervene in the bond market via quantitative easing in order to directly control the bond market rate. Furthermore, liquidity support measures, a second instrument of unconventional monetary policy, were effective in stabilizing the refinancing sources in the banking sector in such a way that banks may refinance their business via longer-term central bank credits. This application of unconventional monetary policy shows that central banks are able to stimulate the financial system also away from the zero-lower bound.

This dissertation further addressed the spillover of bond market effects into the bank credit market, providing justification for further empirical research in this field.

Future research on the monetary paradigm in my opinion should also consider the following issues:

- Heterogeneity in the bank credit and bond markets

  In my dissertation, I assume that the suppliers of liquid funds regard the demand side as homogeneous with respect to credit risk. In the contemporary world, however, credit risk is unequally distributed. For example, sovereigns generally obtain better credit ratings than corporations. Meanwhile, as described in Section 4.3.2, the consumers of credit are driven by different determinants. These determinants must be analyzed in order to conduct a thorough empirical examination of each market. Finally, the banking sector is also assumed to be homogeneous. As the financial crisis has revealed, this assumption may lead to problems, particularly due to contagion risk in the banking sector.

- Introduction of the equity market

  In the model the financial system consists of only two markets, the bank credit market and the bond market. However, the equity market also plays an important role in the economy. Since both markets facilitate the redistribution of money balances, it may be assumed that the equity market functions similarly to the bond market.

However, the motives of equity market investors appear to differ from those of bond market investors, and it is important that this issue be addressed both theoretically and empirically.

- Connection of the financial system to the real sector

  The implications of the description of the financial system developed in my dissertation for the real sector should be analyzed. Jakab and Kumhof (2015) have already demonstrated that the endogenous money creation theory implies a more volatile real economy than does intermediation theory. Theoretically, it is possible to derive a LM curve which takes multiple credit creation in the bank credit and bond markets into account.

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