

Krug, Sebastian; Wohltmann, Hans-Werner

Working Paper

Shadow banking, financial regulation and animal spirits: An ACE approach

Economics Working Paper, No. 2016-08

Provided in Cooperation with:

Christian-Albrechts-University of Kiel, Department of Economics

Suggested Citation: Krug, Sebastian; Wohltmann, Hans-Werner (2016) : Shadow banking, financial regulation and animal spirits: An ACE approach, Economics Working Paper, No. 2016-08, Kiel University, Department of Economics, Kiel

This Version is available at:

<https://hdl.handle.net/10419/142158>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

C | A | U

Christian-Albrechts-Universität zu Kiel

Department of Economics

Economics Working Paper
No 2016-08

shadow banking, financial regulation and animal spirits – an ACE approach

by Sebastian Krug and Hans-Werner Wohltmann

issn 2193-2476



Shadow Banking, Financial Regulation and Animal Spirits – An ACE Approach – *

Sebastian Krug^b and Hans-Werner Wohltmann^k

This version: June 13, 2016

Abstract

Over the past decades, the framework for financing has experienced a fundamental shift from traditional bank lending towards a broader market-based financing of financial assets. As a consequence, regulated banks increasingly focus on coping with regulatory requirements meaning that the resulting funding gap for the real economy is left to the unregulated part of the financial system, i.e. to shadow banks highly relying on securitization and repos. Unfortunately, economic history has shown that unregulated financial intermediation exposes the economy to destabilizing externalities in terms of excessive systemic risk. The arising question is now whether and how it is possible to internalize these externalities via financial regulation.

We aim to shed light on this issue by using an agent-based computational macro-model as experimental lab. The model is augmented with a shadow banking sector representing an alternative investment opportunity for the real sector which shows animal spirit-like, i.e. highly pro-cyclical and myopic, behavior in its investment decision.

We find that an unilateral inclusion of shadow banks into the regulatory framework, i.e. without access to central bank liquidity, has negative effects on monetary policy goals, significantly increases the volatility in growth rates and that its disrupting character materializes in increasing default rates and a higher volatility in the credit-to-GDP gap. However, experiments with a full inclusion, i.e. with access to a lender of last resort, lead to superior outcomes relative to the benchmark without shadow banking activity. Moreover, our results highlight the central role of the access to contagion-free, alternative sources of liquidity within the shadow banking sector.

Key words: Shadow Banking, Financial Stability, Monetary Economics, Macroprudential Policy, Financial Regulation, Agent-based Macroeconomics.

JEL Classification: E44, E50, G01, G28, C63

*We would like to thank Matthias Lengnick, Sander van der Hoog, Benjamin Burghardt, Falko Schläffke, Sven Offick and Stephen Sacht for a lot of fruitful comments.

^bChair for Macroeconomics, Dept. of Economics, Kiel University, Germany, E-mail: s.krug@economics.uni-kiel.de, Tel: +49 431 - 880 1086, Fax: +49 431 - 880 1774

^kChair for Macroeconomics, Dept. of Economics, Kiel University, Germany, E-mail: wohltmann@economics.uni-kiel.de, Tel: +49 431 - 880 1086, Fax: +49 431 - 880 1774

1 Introduction

Over the past decades, the framework for financing has experienced a fundamental shift from the traditional bank-based towards a new and broader market-based credit system entailing new sources of systemic risk [Adrian and Shin (2008); Mehrling (2012); Mehrling et al. (2013)].¹ According to Hoenig (1996), this shift mainly includes the “*growing importance of capital markets in credit intermediation, the emergence of markets for intermediating risks, changes in the activities and risk profiles of financial institutions, and the increasingly global nature of financial intermediation*”.

As a consequence, traditional banks face significant competitive disadvantages forcing them to alter their business model and leaving the resulting funding gap for the real economy to highly specialized non-bank financial intermediaries that can provide liquidity at much lower costs [Martin et al. (2013); Gorton and Metrick (2012a,b); Sunderam (2015)]. The main problem is that such entities exhibit an extensive contribution to systemic risk by carrying out bank-like functions associated with bank-like risks but without being subject to bank-like regulation and without access to a lender of last resort or to public backstops like deposit insurance schemes. Hence, there is a latent risk of runs on these institutions comparable to the situation of traditional banks in the 19th century [Dombret (2014b); Haldane and Qvigstad (2014); Dombret (2013a)]. Such runs can lead to a materialization of idiosyncratic liquidity risk and may force single entities into harmful deleveraging processes. This can negatively affect asset prices bearing the risk of spreading financial distress through the highly interconnected system. Adrian and Ashcraft (2012a) describe the financial frictions involved in shadow banking in great detail. They emphasize that the inherent fragility of this sector is directly related to both sides of shadow banks’ balance sheets, namely to the asset side due to poor underwriting standards while erratic and fickle wholesale funding affects the liabilities side. Paired with investor’s fundamental ignorance of tail risks [Gennaioli et al. (2013)], their collective underestimation of asset correlations (e.g. fire sale externalities, leverage cycles [Geanakoplos (2009); Adrian and Boyarchenko (2012); Martin et al. (2013); Aymanns and Farmer (2015)]) and their animal spirit-like, highly pro-cyclical investment decisions (over-investment during booms and the excessive collapses during bust), unregulated credit intermediation establishes optimal conditions for systemic risk to materialize in the form of financial crises.

Hence, financial supervisory authorities have the difficult task to design an appropriate regulatory regime that restricts loan portfolios and prevents excessive risk-taking to ensure a constant stream of credit to the real sector [Luttrell et al. (2012); Schwarcz (2012); Financial Stability Board (2015)]. The arising question is now whether and how it is possible to internalize these externalities via financial regulation.

The still small but growing amount of studies in this strand is dominated by general equilibrium frameworks, thus, we contribute to the field by presenting an agent-based macro-model with heterogeneous interacting agents, endogenous money and a shadow banking sector representing an alternative investment opportunity for the real sector. The model comprises all main sources of systemic risk associated with unregulated credit intermediation such as animal spirit-like, sudden collective withdrawals of invested funds, runs, fire sales of assets, poor underwriting standards, the evaporation of whole sale funding as well as systemic under-capitalization making it well suited to analyze financial stability issues since these features have been identified as root

¹In this context, Adrian and Shin (2008) state that “[t]he rapid move toward a market-based financial system in recent years has accelerated the trend toward greater reliance on non-traditional, non-deposit-based funding and toward greater use of the interbank market, the market for commercial paper, and asset-backed securities.”.

causes of systemic failures of the past.² Our contribution is to get insights into the effects of an inclusion of the shadow banking sector into the regulatory framework on economic activity and whether such a proceeding would be suitable to internalize the described destabilizing externalities without limiting shadow banking activity per se, i.e. we shed light on how to make the most out of it. Moreover, the present paper is useful to understand the central role of the access to contagion-free, alternative sources of liquidity within the shadow banking sector.

Our experiments provide three main findings. First, our results suggest that switching the regulatory regime from “*regulation by institutional form*” to a “*regulation by function*” meaning the inclusion of shadow banks into the regulatory framework, as proposed by Mehrling (2012), seems to be worthwhile in terms of the internalization of systemic risk.

Second, supervisory authorities should do so in a coordinated and complete manner. A unilateral inclusion, i.e. burdening the shadow banking sector with the same regulatory requirements as traditional banks but denying the access to the public safety net leads to inferior outcomes compared to the benchmark case without shadow banking activity and even to the case in which they are not regulated at all. The results of such cases include negative effects on primary monetary policy goals, significantly increases in the volatility of growth rates as well as financial and real sector default rates. Moreover, a higher volatility in the credit-to-GDP gap can also be observed which is a common indicator for excessive credit growth and, thus, for financial crises.

Finally, experiments with a full and complete inclusion, i.e. with access to a lender of last resort, lead to superior outcomes in terms of the central bank’s dual mandate, economic growth and financial stability suggesting that a full inclusion of the shadow banking sector into the regulatory framework could indeed, from a theoretical point of view, lead to a significant mitigation of the destabilizing externalities accompanied by their fragile funding model and to a suitable exploitation of their liquidity provision capacity in terms of sustainable growth.

The remainder of the paper is organized as follows: in section 2, we give a brief overview of the currently existing literature on the regulation of shadow banks. Then, in section 3, we present an overview of the structure of the underlying ACE macro model followed by a detailed description of the conducted experiments in section 4. Section 5 provides a discussion of experiment results in terms of macroeconomic and financial stability. Section 6 concludes.

2 Related Literature

Concerning the existing literature, Meeks et al. (2014) emphasizes in general that, “[u]ntil now, few papers have attempted to model shadow banking in a macroeconomic context”. In particular, the strand on the regulation of shadow banking activity mainly includes either studies that develop principles aiming to guide future regulatory reforms or studies using simple two- or three-period models as well as DSGE models to shed some light on these issues. Hence, to the best of our knowledge, the set of model classes used to explore the effects of shadow banking on economic activity is yet limited to (general) *equilibrium* frameworks. An early three-state formal model is presented by Gennaioli et al. (2013) which builds on the production model from Gennaioli et al. (2012) and introduces shadow banking in order to show that financial innovation has contributed to the build up of systemic risk. Moreover, they show that in a world with shadow banking and myopic investors which systematically neglect tail risks, a sufficiently large

²Bookstaber (2012) and Battiston et al. (2016) strongly argue in favor of agent-based computational (ACE) frameworks to do research on financial stability and related policy issues. For a good overview on current DSGE models including shadow banking, see Meeks et al. (2014).

degree of maturity transformation and leverage lead to credit booms and busts. [di Iasio and Pozsar \(2015\)](#) use a simple two-period model to analyze capital and liquidity regulation in a market-based intermediation system while [Ricks \(2010\)](#) studies potential approaches to policy intervention within a simple risk model and proposes a risk threshold for financial intermediaries. Additionally, the author discusses the externalities accompanied by the inherently fragile funding scheme of shadow banks. Furthermore, [Plantin \(2014\)](#) shows that the regulatory arbitrage-channel serves as explanation for the massive growth of the shadow banking sector using a simple two-state equilibrium model of optimal bank capital.

Concerning a possible future regulation of shadow banking, [Schwarcz \(2013, 2012\)](#) provides a general assessment of the trade-off between higher efficiency in the financial system through the existence of shadow banks and their contribution to systemic risk. The author argues not to limit shadow banking activity per se and, instead, favors an inclusion of shadow banking activity which should be conducted in such a way that efficiencies are maximized and the contribution to systemic risk is minimized. In this regard, [Gorton and Metrick \(2012a,b\)](#) describe two mechanisms that have led to the collapse of particular sectors in the shadow banking system and [Gorton and Metrick \(2013\)](#) emphasize the important role of the FED in their function as lender of last resort. Moreover, [Gorton and Metrick \(2010\)](#) identify three main factors of shadow banking activity, namely *i*) the emergence of money-market mutual funds (MMFs) that pool retail deposits, *ii*) the securitization process³ to move assets off balance sheets, and *iii*) repurchase agreements (repos) that facilitated the use of securitized bonds as money. Further, the authors conclude that the key to a regulation of privately created money is a combination of strict guidelines on collateral for securitization and repos as well as a government-guaranteed insurance for MMFs. Finally, [Adrian and Ashcraft \(2012b\)](#) provide a conceptual framework for future regulatory reforms and describe the relevant financial frictions to consider in this regard.

There has also been increasing concern with introducing banking into the DGSE world. These few existing studies mainly focus on the role of credit-supply factors governing credit growth in business cycle fluctuations, i.e. they focus on the role of financial intermediaries rather than on the mechanisms of the borrower or demand-side as, for instance, in the seminal work of [Bernanke et al. \(1999\)](#). The first attempts in this direction are the studies of [Gerali et al. \(2010\)](#); [Meh and Moran \(2010\)](#) and [Gertler and Karadi \(2011\)](#). The authors show the presence of the bank balance sheet channel to improve the DSGE model's fit to the data. However, [Meeks et al. \(2014\)](#) criticize that in these papers, the entire financial system is represented by traditional intermediaries. Thus, they contribute to the literature by constructing a standard dynamic general equilibrium macro model that captures some key features of an economy in which traditional and shadow banks interact by implementing two types of financial intermediaries and a securitization process. In this setting, traditional banks are able to offload their risky loan portfolio onto the shadow banking sector and to trade the securitized assets which allows *“for heterogeneity and specialization in the functions of [financial] intermediaries, generating an additional source of dynamics”*. Within this framework, they analyze responses of aggregate economic activity, the supply of liquidity and credit spreads to business cycle and financial shocks. Another paper to mention is presented by [Verona et al. \(2013\)](#) who introduce shadow banking into a sticky price DSGE model by likewise adding a distinct class of financial intermediaries to study the effect of low interest rates environments on the financial system. However, the approach lacks securitization and there is no direct link between the regulated and unregulated part of the financial system. We also want to highlight the work of [Goodhart](#)

³According to [Adrian and Shin \(2009\)](#), *“[s]ecuritization was intended as a way to transfer credit risk to those better able to absorb losses, but instead it increased the fragility of the entire financial system by allowing banks and other intermediaries to ‘leverage up’ by buying one another’s securities”*.

et al. (2012) who study a wide range of macroprudential tools in a stylized two period general equilibrium model and show how fire sale dynamics can exacerbate financial constraints.

Finally, Arnold et al. (2012) provides an overview of the progress made in measuring systemic risk and of the remaining challenges in that field. Moreover, the authors also discuss in which sense shadow banks represent a significant factor that drives the build up of systemic risk. For a more general view on systemic risk in modern economies, see Montagna (2016).

To the best of our knowledge, there is yet no paper covering shadow banking and its prudential regulation using a comparable (agent-based) approach.

3 Model Summary

The paper is primarily focused on the impact of shadow banking on economic activity, excessive credit growth and the prudential regulation of this sector. Hence, due to space constraints, we do not want to burden the text with a full model description. Therefore, the following section only provides a brief overview of the essential parts of the model that are necessary to follow our analysis.

3.1 General Characteristics

The basic version of the used stock-flow-consistent agent-based macro model (SFC-ACE) was developed during the work of Krug (2015) where the author analyses the interaction between monetary and macroprudential policy. Figure 1 provides an overview of the modeled sectors and the corresponding relationships between types of agents on a monetary level. Thus, the artificial macroeconomy can be characterized by a high degree of financialization in which firms demand credit from the financial sector to finance their production.⁴ It consists of six types of agents, i.e. households and firms (real sector), a central bank, a government and a financial supervisory authority⁵ (public sector) and a set of traditional banks (financial sector). Agents are heterogeneous in their initial endowments of e.g. productivity, amount of employees or clients and interact through a goods, labor and money market in order to follow their own needs like consuming or making profit. Along the business cycle, the economy follows *Minskyan* dynamics with firms transitioning between various stages of financial soundness, i.e. hedge, speculative and Ponzi finance⁶ [Minsky (1986)], representing the root cause for severe financial crises.⁷

Moreover, economic activity is guided by monetary policy which is implemented as usual in developed countries by setting a target rate that directly affects the whole set of existing interest rates, in particular the rates charged on loans to the real sector by means of increased refinancing costs. Through the resulting effect on credit demand, the CB's monetary policy

⁴Note that in this version of the model, households yet do not demand any credit from the banking sector. In order to be able to analyze the impact of a wider range of macroprudential tools concerning consumer credit, i.e. like the loan-to-value (LTV) or the debt-to-income (DTI) ratio, an extension of the model in this direction would be necessary.

⁵This type of agent is not depicted in figure 1 since it is not involved in any monetary flows.

⁶Shadow banking contributes to the shift towards more fragile Minskyan funding forms (speculative and Ponzi) since the lending activity of traditional banks focuses on hedge financed firms by charging a sufficiently high risk premium. However, shadow banks do not fully compensate for a higher default risk of their customers in the same manner and tend to have more loose underwriting standards. Hence, the fraction of fragile funding forms increases with the size of the shadow banking sector and so does overall systemic risk [Chernenko and Sunderam (2014)].

⁷The share of the three financing schemes proposed by Minsky varies over time and is seen as a main source of fluctuations of the *financial cycle* [Drehmann et al. (2012); Adrian and Shin (2008); Claessens et al. (2012); Borio (2014); van der Hoog and Dawid (2015); Strohsal et al. (2015a,b); Galati et al. (2016)].

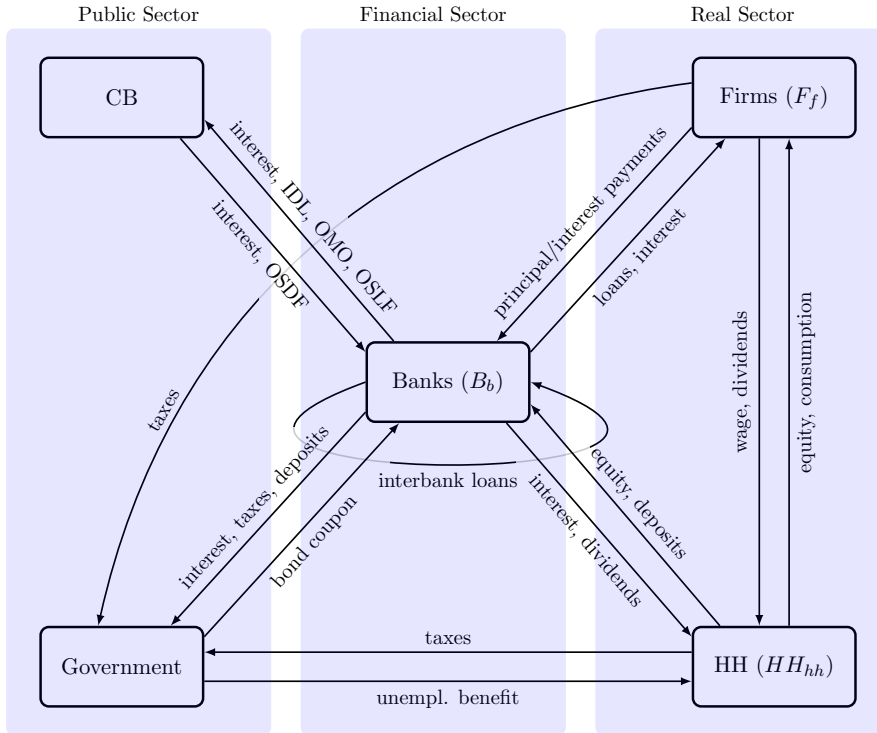


Figure 1: Monetary flows in the basic version of the underlying model developed in [Krug \(2015\)](#)

transmits to overall economic activity, i.e. to production and price levels and, thus, to inflation and output.

As a result of the interaction of heterogeneous agents, the model exhibits common macroeconomic stylized facts emerging through the course of the simulation such as endogenous business cycles, GDP growth, unemployment rate fluctuations, balance sheet dynamics, leverage/credit cycles and constraints, bank defaults and financial crises, as well as the need for the public sector to stabilize the economy [shown in [Krug \(2015\)](#)].

For this paper, we extend the basic version of the model in the following way: beside the traditional and regulated banking sector with all its safety net-features like deposit insurance against bank runs and the liquidity insurance given by the central bank (LOLR function), we implement a so-called “*parallel banking system*”, i.e. a co-existing financial sub-system comprising of various independent, specialist non-banks raising an interconnected network of balance sheets that operates completely external to regulated banks and the public safety net [[Pozsar et al. \(2010\)](#)]. This sub-system finances itself through investments of HHs since it represents an alternative investment opportunity with a higher yield compared to the interest on deposits paid by traditional banks [see [subsection 3.4.3](#) for a detailed description of the HH’s decision process]. The shadow banking activity is modeled in a way to implement the negative effects of extreme short-term funding structures (wholesale or money market funding), a high degree of pro-cyclicality and the on/off-character of the availability of liquidity in market-based credit systems. Of course, the manifestation of these effects depend on the relative size of the unregulated sub-system and, hence, shadow banking is not a bad thing in itself. Used in a prudential manner, it can even contribute to a prospering economy by serving as an alternative source of liquidity for parts of the real sector that would be credit rationed in the absence of shadow banks [[Dombret \(2013a, 2014a\)](#)]. [Pozsar et al. \(2010\)](#), among others, describe the shadow banking pro-

cess in great detail, but due to the high degree of complexity and opaqueness, we do not model the whole process with all its dozens of specialist entities involved. For the sake of simplicity, we decide to model just the “head and tail” of the shadow banking process, i.e. we add two classes of agents, one being “*Money-market Mutual Funds (MMF)*” which serves as a cash pool for the investments of the households and “*Broker-dealers (BD)*” who grant loans to firms and finance these via secured (overnight) repos with the MMF. Figure 2 shows the extended parts in red color. Subsection 3.4 provides a detailed description of the way the shadow banking process is modeled.

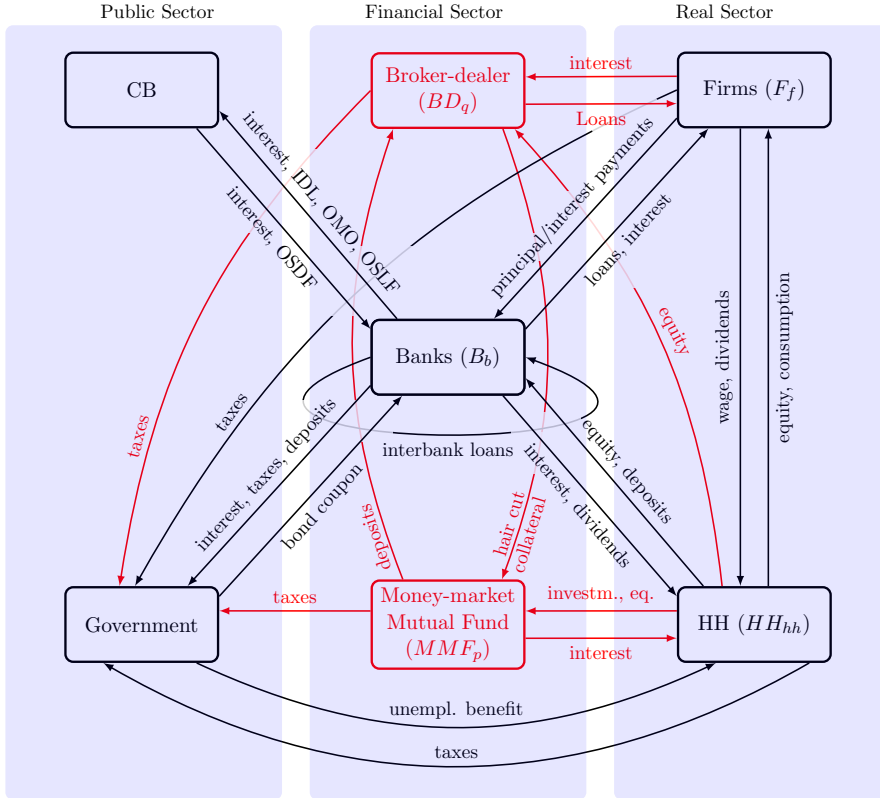


Figure 2: Monetary flows in the extended model with shadow banking

3.2 Sequence of Simulated Economic Activity (Pseudo Code)

In this section, we show the economic activities as they occur during the simulation process. This should impart a rough idea of the functionality of the underlying agent-based macro-model and its consisting parts. The rest of the section describes these parts in more detail.

1. Start economic interaction of settlement period t ($t = 1, \dots, 3000$)
 - Banks settle their overnight/short-term interbank liabilities (if any)
 - Banks settle their overnight/short-term standing facility liabilities with the CB (if any)
 - Banks set up repos with CB of maintenance period (if new periods starts)
2. Shadow bank activity

- Reactivation of shadow banks (if any)
 - HH adjust their speculative funds
 - MMF decide about to roll over their repos
 - BD repurchase collateral (if any)
 - MMF repay withdrawn funds to HH (if any)
 - BD securitize and sell loan portfolio
 - BD do new overnight repos with MMF (if any)
3. Real sector activity (planning phase)
- Reactivation of firms (if any)
 - Firms determine their production target
 - Firms determine their offered wage
 - Firms determine their credit demand (external financing)
 - Firms send credit requests to traditional and shadow banks (sequentially⁸)
 - Firms announce vacancies
 - Firms fire employees if they face an overproduction (if any)
4. Government pays unemployment benefit to unemployed HH
5. Real sector activity (production phase)
- Unemployed HH search for a job / firms hire workers in case of a match
 - Firms produce and offer their bundle of goods
 - HH plan and conduct consumption
6. Real/public sector debt obligations
- Firms pay wages and meet their debt obligations (risk for firm default due to illiquidity)
 - Government pays principal/interest on outstanding bonds
 - Test for firm default due to insolvency
7. End of settlement period t
- Banks determine their profit / pay taxes (if any) / pay dividends to HH (if any)
 - Banks repay intra day liquidity (IDL) to the CB (if any)
 - Banks conduct interbank lending (overnight)
 - Banks use standing facility of the CB
 - CB pays interest on reserves
 - Test for insolvencies of financial sector agents (trad. banks/shadow banks)
 - Government bail out of systemically important (i.e. large traditional) banks

⁸Here, sequentially means that firms send credit requests to traditional banks first and in the case of a refusal they try to use the shadow banking sector as alternative source of liquidity.

8. Monetary policy decisions

- CB sets target rate
- adjustment of the market sentiment parameter (PCL)
- CB sets counter-cyclical buffer

3.3 Settlement Period

The underlying monetary framework of the model follows the theory of endogenous money [see [Lavoie \(2003\)](#) among others], i.e. the amount of money in the system is determined by the investment decisions of real sector agents (demand-driven) instead of the supply of the CB (supply-driven). To model this feature in the most consistent way, we decided to implement a monetary system along the lines of the *UK Sterling Monetary Framework* of the Bank of England (BoE) using it as a template.⁹ The orientation seems to be reasonable, since the BoE itself recently attracted attention in the field by implicitly accepting endogenous money theory in their in-house journal, the *BoE Quarterly Bulletin* [[McLeay et al. \(2014a,b\)](#)].

At the heart of the UK reserve averaging scheme¹⁰ lies a *real-time gross settlement* (RTGS) system [[Kelsey and Rickenbach \(2014\)](#); [Dent and Dison \(2012\)](#); [Nakajima \(2011\)](#); [Arciero et al. \(2009\)](#)] which enables the CB to provide liquidity insurance to commercial banks via operational standing facilities (OSF) and, thus, to meet its lender of last resort (LOLR) function. This means that the settlement of a transaction between real sector agents takes place as soon as a payment is submitted into the system (real-time) and that a payment can only be settled if the paying bank has enough funds to deliver the *full* amount in central bank money (gross settlement, i.e. no netting takes place) [[Galbiati and Soramäki \(2011\)](#)].¹¹ Banks have to finance their reserve accounts for the current maintenance period¹² in advance by setting a target average for their reserve holdings as a fraction of their current interest bearing deposits and by pledging a suitable amount of collateral with the CB [[Ryan-Collins et al. \(2012\)](#)]. In turn, banks' reserve holdings are remunerated at the CB's target rate i_t^* on a period average basis. For that reason, the CB defines a narrow 1%-range around the individual target balance of each bank and depending on whether the bank has met its reserve target range or not, it will be credited with the interest earned against its average balance at the end of each maintenance period.

However, through the course of the maintenance period, each bank faces an unpredictable stream of transactions between real sector agents each affecting banks' reserve balances. Thus, economic activity usually leads banks to end up with an average reserve balance outside of their reserve target range, i.e. with either excess reserves or a reserve deficit. To ensure the compliance with the target range, banks are encouraged to appropriately manage their liquidity. By charging a premium (discount) on the target rate i_t^* for the usage of its lending (deposit) facility, the CB builds an interest corridor which ensures that banks seek money first in the

⁹A good description can be found in [Bank of England \(2014b\)](#); [Ryan-Collins et al. \(2012\)](#).

¹⁰Although it was suspended after the recent financial crisis in 2009 and a Quantitative Easing (QE) scheme is prevailing instead, the reserve averaging scheme can be considered as the default scheme implemented in normal times. With respect to the aim of the model, i.e. to evaluate monetary policies contribution to financial stability, a scheme with a comparable setting to the pre-crisis period of 2007/2008 seems to be a reasonable choice.

¹¹We suppose that all transactions in the overdraft economy are conducted by only using scriptural money, i.e. there exist no banknotes (cashless economy).

¹²The maintenance period means the time between the target rate decisions of CB. In reality, the maintenance period of the BoE lasts 4 weeks and banks have to settle their reserve accounts with the BoE at the end of each business day. Hence, the modeled maintenance period lasts for 4 settlement periods.

open (interbank) money market and reallocate outstanding reserves through overnight repos with peers before turning to the CB's standing facilities¹³ [compare Lavoie (2003)].

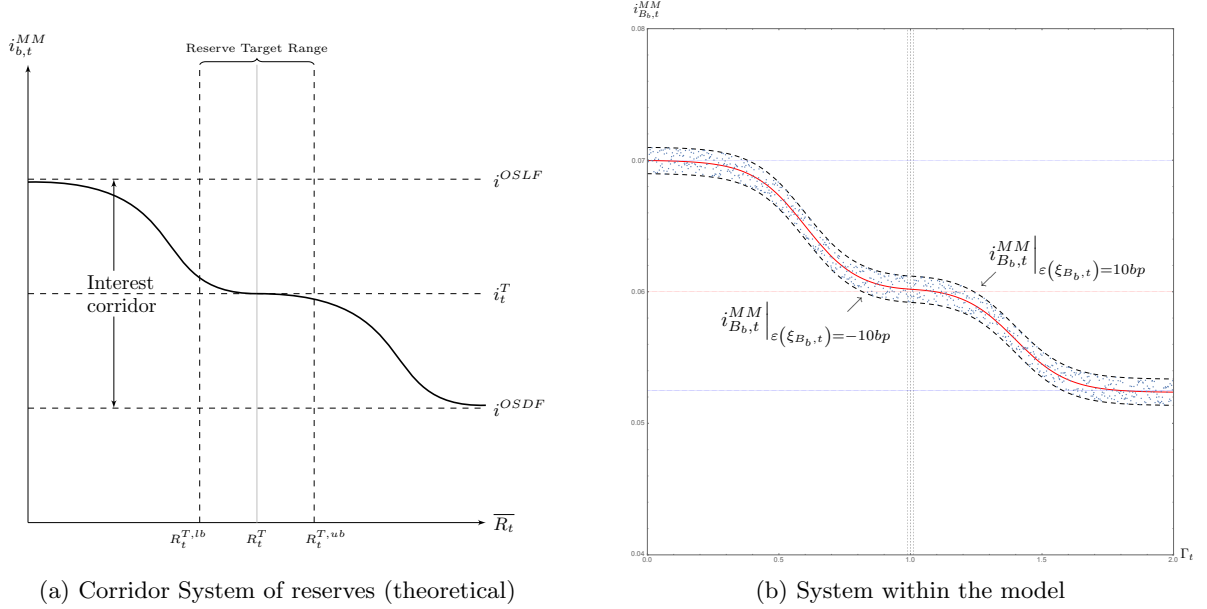


Figure 3: Money market rate, banks' demand for reserves and the interest corridor of the CB [Bank of England (2014b); Ryan-Collins et al. (2012); Winters (2012)]

We model the interbank market as a (decentralized) over-the-counter (OTC) market which requires bank b (in need of reserves) to find a counterparty within the set of all other banks that is willing to lend reserves to b [Afonso and Lagos (2013)]. The conditions for overnight interbank repos are then based on bilateral negotiation about volume and interest charged ($i_{b,t}^{MM}$). Whereas the volume depends on the counterparty's current excess reserves, the money market rate $i_{b,t}^{MM}$ faced by b depends on i_t^* , on the current financial soundness of bank b and on the current supply of excess reserves on the money market expressed by

$$\Gamma_t = \frac{\sum_{b=1}^B \bar{R}_{b,t}}{\sum_{b=1}^B R_{b,t}^*} = \frac{\bar{R}_t}{R_t^*} \quad (1)$$

which serves as a measure for how far the current aggregate average reserves (\bar{R}_t) are away from the aggregate reserve target (R_t^*). Hence, the prevailing incentives scheme shown in figure 3a leads to an individual money market rate for bank b of

$$i_{b,t}^{MM}(i_t^*, \Gamma_t, \xi_{b,t}) = \left\{ g(\Gamma_t) \left[\sigma_1 - \sigma_2 \cdot \tanh\left(\varphi\Gamma_t - \frac{3}{2}\varphi\right) \right] + \left(1 - g(\Gamma_t)\right) \left[\sigma_3 - \sigma_4 \cdot \tanh\left(\varphi\Gamma_t - \frac{\varphi}{2}\right) \right] \right\} - (0.06 - i_t^*) + \varepsilon(\xi_{b,t}) \quad (2)$$

¹³Beside the standing facilities, the liquidity insurance of the CB also encompasses secured short-term repos for banks in need of reserves *during the course of the settlement period*. These reserves are referred to *intraday liquidity* (IDL) and have to be repaid at the end of the settlement period just before banks take action to meet their individual reserve target range [Bank of England (2014a); Dent and Dison (2012); Ryan-Collins et al. (2012)]. So, the provision of IDL ensures that any payment of a banks' client can be settled in real-time and on a gross basis.

with

$$g(\Gamma_t) = \frac{1}{2} + \frac{1}{2} \tanh\left(\frac{\Gamma_t - 1}{0.1}\right) \quad (3)$$

as well as $\varepsilon(\xi_{b,t})$ representing a small risk premium/discount (between +10 and -10 basis points) depending on b 's financial soundness measured by its D/E-ratio $\xi_{b,t}$. Hence, realizations of $i_{b,t}^{MM}$ fall within the scope of a small band around $i_{b,t}^{MM}\Big|_{\varepsilon(\xi_{b,t})=0}$ (figure 3b shows this exemplary for $\Gamma_t \in (0, 2)$). Table 1 shows the corresponding interest corridor build by the lending/deposit facility rates which depends on the current target rate i_t^* as well as the parameter sets for σ_1 , σ_2 , σ_3 and σ_4 .¹⁴

Note that the reserve allocation process of the model's payment system is not perfect in the sense that the search for a counterparty with excess reserves is not always successful. This can be for various reasons, for instance, the banks with excess reserves do not want to lend to other banks because they have to offset a former deficit state or they show, in general, a highly risk-averse behavior in the aftermath of a default of a peer. Such a behavior corresponds with the freeze of the interbank market that could have been observed after the default of Lehman Brothers. Another reason could be that the bank in need of reserves has a very bad financial soundness and only this bank is forced to turn to the central bank while others are still able to obtain reserves from peers.

Table 1: Parameter sets determining the level of the CB's interest corridor

i_t^{OSDF}	i_t^*	i_t^{OSLF}	σ_1	σ_2	σ_3	σ_4
$i_t^* - 0.75\%$	$i_t^* \geq 5\%$	$i_t^* + 1\%$	$\sigma_3 - 0.00865$	0.004	0.065	0.005
$i_t^* - 0.45\%$	$i_t^* \leq 5\%$	$i_t^* + 0.5\%$	$\sigma_3 - 0.005$	0.0025	0.0625	0.0025
$\max(i_t^* - 0.25\%, 0.25\%)$	$i_t^* < 3\%$	$i_t^* + 0.25\%$	$\sigma_3 - 0.0025$	0.00125	0.06125	0.00125

3.4 Shadow Banking

Shadow Banking mimics the traditional financial intermediation process by disassembling it into its parts or services and by providing every service through a highly specialized and unregulated entity. This proceeding is not only very complex in nature, it is also accompanied by several sources of systemic risk well-known from banking in the 19th century when the first central banks were established to regulate the fully free operating banking sector, in particular, to mitigate the negative externalities of excessive maturity and liquidity mismatches [Haldane and Qvigstad (2014); Mehrling et al. (2013)].

Hence, these sources mainly include the susceptibility to runs due to the lack of an appropriate (deposit) insurance scheme [Gorton and Metrick (2012b)], extreme levels of leverage as well as the immense liquidity or roll-over risk faced by shadow banks in combination with the lacking access to a LOLR-institution. In particular, the predominant reliance on institutional funds and its concentration in wholesale funding markets play an important role. Unlike retail deposits, these funds are well-informed, herd-like, i.e. highly sensitive to news, and badly diversified. This mainly stems from the fact that the institutional investor's intention is yield rather than storing and security. Another issue contributing to the fragility of the shadow banking system is the form of withdrawals. The predictability of retail-deposit withdrawals is much higher since they

¹⁴We calibrated the parameters according to data on the interest rate corridor of the BoE and the FED which show that the corridor widens with an increasing target rate.

require an active decision of the depositor to withdraw funds from its account. In wholesale funding markets where (overnight) repos are the contractual form of choice, it is the exact opposite, i.e. investors have to decide actively about the roll-over of their lent funds. For traditional banks, the analogous situation would be that every depositor would have to actively decide and communicate every evening whether he still agrees to place his funds with the bank until the next day or not, and moreover, if he does nothing at all, the money would automatically be withdrawn from the bank.

As such, we frame shadow banks as *unregulated and extremely leveraged entities without any link to resilient, contagion-free liquidity sources or insurance schemes that exhibit a wholesale funding model which is highly exposed to the fickle and herd-like decisions of investors and revulsions in overall market sentiment*.

According to [Pozsar et al. (2010); Pozsar (2014)] there is usually an entity which serves as an institutional cash pool, like a pension, hedge or money-market fund promising a relatively safe but higher yield compared to traditional banks. To earn the promised yield, the fund lends the collected funds against collateral (typically via secured overnight repos) to other entities that are in need of liquidity and have large amounts of securitized assets on their balance sheets [Chernenko and Sunderam (2014); Dombret (2014a)]. These entities build the core of the highly complex shadow banking process and for the sake of simplicity, we follow the approach of previous studies in the field and do not explicitly model this process in great detail [Meeks et al. (2014), among others]. At the other end of the process, one typically finds entities that provide liquidity to the real sector, like a broker-dealer [Rosengren (2014)], but do not want to hold the highly illiquid assets until maturity on their balance sheets in order to avoid the risks stemming from credit, liquidity and maturity transformation accompanied with traditional financial intermediation [Pozsar (2015)]. That is why these assets are distributed through the securitization process finally ending up at the cash pooling fund and the liquidity from the fund ends up at the broker-dealer completing the shadow banking intermediation process. Thus, we explicitly model the *head and tail* of this process by introducing two new classes of agents, i.e. a money-market mutual fund (MMMF) that pools the cash of investors and a broker-dealer (BD) that serves as alternative source for credit for the real sector. The latter finances itself through extremely short-term (overnight) repos with the MMMF. Figure 4 shows the differences between the traditional and shadow banking intermediation process in the model.

The rest of the section describes the business of these new types of agents and their range of activities in more detail, followed by a description of the investment decision of HHs.

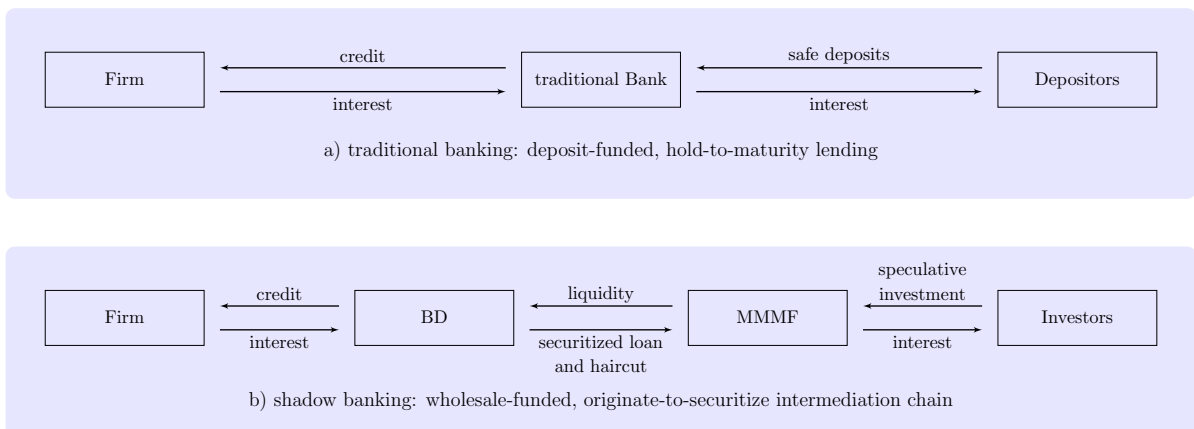


Figure 4: Lending activity in the traditional and shadow banking sector

meet the withdrawals of its investors, it also defaults and is resolved passing the loss over to the investors.

3.4.2 Broker-Dealer – The Non-bank Provider of Credit

Our aim is to implement the typical broker-dealer funding model with all associated risks as described in e.g. [Rosengren \(2014\)](#). It includes large balance sheets with risky long-term assets mainly funded at low costs, i.e. short-term fully collateralized loans at a quite low interest or haircut (repurchase agreements). Unfortunately, such a business model requires prospering and booming phases in order to be profitable and highly depends on the availability of liquidity to roll over the broker-dealer’s debt. However, during times of financial distress, that low-cost funding quickly evaporates. In this regard, [Rosengren \(2014\)](#) states that

“[d]uring the financial crisis, we saw that many of those who traditionally lent to broker-dealers feared default by a broker-dealer – and did not want to risk having to take possession of the collateral associated with the repurchase agreement in the event of a default. In fact, money market mutual funds, one of the largest sources of lending to broker-dealers, are prohibited from purchasing the kind of long-term or high-credit-risk assets that are sometimes pledged as collateral for loans to broker-dealers. [...] The result is that broker-dealers can experience significant funding problems during times of financial stress”.

The economic activity of broker-dealers in the model can be described as follows: After its foundation, the broker-dealer grants initial loans to firms and securitizes the resulting long-term asset in order to place it as collateral for a repo with a MMF. The new liquidity can now be used for further loans proceeding in the same way while balance sheets expand and profit rise.

Regulatory tools are designed to prevent from greedy tendencies gaining the upper hand, in particular during prospering phases, and, hence, a significant share of the credit demand cannot be met by traditional banks. Due to the mentioned cost advantages of its intermediation strategy, the broker-dealer can offer loans at more favorable conditions to firms than traditional banks. More detailed information about the interest level can be found in [subsection 3.6](#). Another point that increases the attractiveness of shadow banks is that they have rather loose underwriting standards since they are not forced to comply with corresponding regulatory requirements and usually distribute the originated assets through securitization. Hence, the modeled broker-dealer agents cover this feature by neglecting the evaluation of its client’s creditworthiness. As a consequence and since every credit request represents an opportunity to make profit, the only channel that restricts the lending activity is the lack of sufficiently liquid MMFs. This comes to the fact that the shadow banking sector also finances the less creditworthy part of the real sector while traditional banks are incentivized not to lend to these firms through regulation. Thus, increasing shadow bank activity not just negatively affects the distribution of the Minskyan financing schemes towards instability by itself, but also by functioning as an amplifier through lending to financially unsound firms.

3.4.3 Investment Decision of Households

The extension of the model by shadow banking also includes an alternative investment opportunity for HHs in MMFs instead of just leaving their funds at traditional banks. This section describes the decision process involved.

Once a month, each HH decides on whether to adjust its investment into the shadow banking sector or not. This involves a two-stage-decision process where the result depends on both the

recent development of the market sentiment and household's individual degree of risk aversion. The overall market sentiment¹⁵ is modeled by a *public confidence level* (PCL),¹⁶ i.e. the agents' expectations about the future economic activity within the artificial economy. This market sentiment negatively depends on the prevailing interest environment with the central banks' target rate at its core. This is in line with the risk channel-theory which says that a low-interest environment leads to a *seek-for-yield* behavior accompanied by a higher risk tolerance of market participants [Borio and Zhu (2012)].

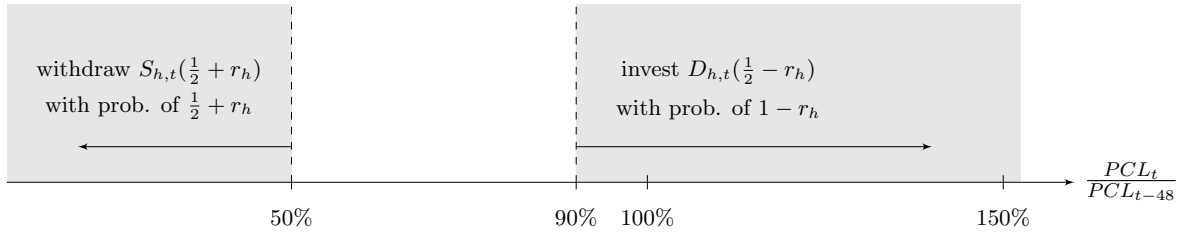


Figure 6: Investment decision of HH h in t

r_h represents the risk-aversion parameter of HH h which is randomly distributed between 0 and 0.5 and stays fixed for the rest of the simulation, $S_{h,t} :=$ already invested funds of HH h in t , $D_{h,t} :=$ fraction of deposits of HH h in t held at its traditional bank account available for speculative investments.

To model the typical inherent myopia of investor's decisions, we link the investor's assessment of the current market situation to the short-run development of the market sentiment, i.e. HHs compare the current level of market sentiment (PCL_t) with its development during the recent past, i.e. with the level one year ago (PCL_{t-48}).¹⁷ Hence, the PCL depends on and reacts to (short-run) changes of the central bank's target rate:

$$PCL_t(i_t^T) = 1.1 - 10i_t^T. \quad (4)$$

In this regard, one could say that HHs act similar to chartists known from the financial markets literature and that their behavior is mainly driven by "animal spirits" [Keynes (1936); Akerlof and Shiller (2009)]. Figure 6 shows that if the change in market sentiment, either positive or negative, is relatively large, it then depends on the household's individual risk-aversion parameter r_h whether it immediately responds to the changes or not. For instance, if the overall market sentiment has declined sufficiently, the probability to *withdraw* its funds from the MMF increases with r_h , while the probability to *invest* negatively depends on r_h during euphoric times.

In a second step, after the HH has decided to react to the changes in market sentiment, it decides about the amount to invest/withdraw:

$$\frac{PCL_t}{PCL_{t-48}} = \begin{cases} > 0.9 & \implies \text{invest } D_{h,t}(\frac{1}{2} - r_h) \text{ with prob. of } 1 - r_h \\ < 0.5 & \implies \text{withdraw } S_{h,t}(\frac{1}{2} + r_h) \text{ with prob. of } \frac{1}{2} + r_h, \\ \text{otherwise} & \implies \text{do nothing} \end{cases} \quad (5)$$

¹⁵The approach of an endogenous market sentiment has some analogy with switching mechanisms resulting from agents' limited capacity to process information (bounded rationality of agents) used, for instance, in De Grauwe (2011); Lengnick and Wohltmann (2016), among others. In these papers, agents endogenously switch between optimistic and pessimistic sentiments or between acting as chartists and fundamentalists on the financial markets.

¹⁶A comparable index would be the German *Ifo-Index* of the Munich Economic Institute which also calls market participants and asks them for their current evaluation of the market sentiment.

¹⁷Note, that the periods within the model represent weeks and that a modeled year has $12 * 4 = 48$ weeks. Thus, a value of the previous year has the index $t - 48$ while a value of the previous quarter has the index $t - 12$.

Hence, the HH’s assessment represents a rather myopic and local consideration of the market which represents well-known phenomena like highly pro-cyclical and herding behavior of market participants. Since HHs make their investment decision in such a boundedly rational way, they also want to invest into the shadow banking sector at low interest levels as long as the PCL_t exceeds the PCL_{t-48} by a sufficient amount. HHs then decide to either invest more, withdraw a fraction of their already invested funds or leave their investment at the current level. [Figure 7](#) shows the typical highly erratic development of funds invested in the shadow banking sector. A common decision to withdraw leads to runs on MMF triggering a highly contagious chain of deleveraging processes among financial sector agents.

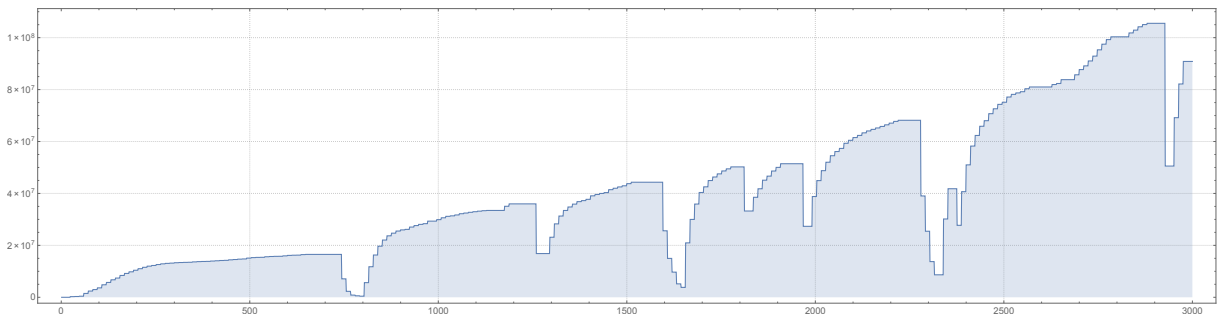


Figure 7: Typical development of invested funds in the shadow banking sector within the model

3.5 Real Sector Activity

At first, firms plan their production for the period as well as the corresponding costs (including wages) which, in turn, determines their current credit demand. The planned production is based on a target value for the firm’s capacity utilization, i.e. it depends on average sales of past periods and a surcharge to cope with demand fluctuations. Moreover, the production function for the period output faced by each firm is of the Cobb-Douglas-type

$$q_{f,t} = (A_t \Psi_{f,t})^{1-\alpha} \quad (6)$$

with aggregate labor skill currently used by firm f ($\Psi_{f,t}$) as input and technology parameter A_t representing technological progress¹⁸ since labor productivity of HHs grows at a constant exogenous rate of $g_A = 0.012$ annually (or $g_A^Q = 0.003$ per quarter), i.e.

$$A_t = A_{t-12} \exp(g_A^Q). \quad (7)$$

When plans are completed, firms request credit from traditional or shadow banks (this is described in more detail in [subsection 3.6](#)) and announce vacancies depending on their financial resources. The firm’s ability to meet its labor demand influences the offered wage of the subsequent periods accordingly.

At this stage, unemployed HHs receive unemployment benefit from the government¹⁹ and start searching for a job. If there is a match between the offered amount of labor skill of a

¹⁸The technology of firms follows the work of [Stolzenburg \(2015\)](#) where the author implements parts of the famous *Solow growth model* [[Solow \(1956\)](#)] into an agent-based framework.

¹⁹The government expenditures for unemployment benefit to HH and interest on outstanding public debt are financed by raising income taxes on wages ($\tau^I = 30\%$), a VAT on the consumption of goods ($\tau^{VAT} = 20\%$), a corporate tax on profits of firms, traditional and shadow banks ($\tau^C = 60\%$), and a tax on capital gains ($\tau^{CG} = 25\%$).

HH and the labor demand of a firm, the HH is hired and stays unemployed otherwise. Then production takes place according to the firm's current production capacity. After production is completed, the output²⁰ is offered on the goods market at retail prices $p_{f,t}$ that account for (individual) expected unit costs including a mark-up ($\mu > 1$) as well as expected inflation (π_t^e)

$$p_{f,t} = (\mu + \pi_t^e) \cdot \frac{12 \cdot q_{f,t}^{-1}(q_{f,t}^*)w_{f,t} + \mathcal{L}_{f,t}i_{b,f,t}}{12 \cdot q_{f,t}^*}. \quad (8)$$

Expected unit costs include wages denoted by $w_{f,t}$ and scaled by the produced quantity $q_{f,t}^{-1}(q_{f,t}^*)$ as well as cost of debt denoted by $\mathcal{L}_{f,t}i_{b,f,t}$. Price revisions occur once a year.

HHs plan their period consumption level, $c_{h,t}^p$, and update it once a quarter. It is composed of an autonomous part

$$c_{h,t}^a = 0.18 \cdot \frac{1}{F} \sum_{f=1}^F w_{f,t-12} \quad (9)$$

co-varying with the average wage of the previous quarter and a part depending more on the current individual financial situation of HH h , i.e.

$$c_{h,t}^p = \min \left[D_{h,t}, \eta c_{h,t-12}^p + (1 - \eta)(c_{h,t}^a + \eta \overline{I_{h,t-12}}) \right] \quad \text{with } \eta = 0.9 \quad (10)$$

where η represents the HH's adjustment speed to new levels of income and $\overline{I_{h,t-12}}$ the average income of the previous quarter including received wages, interest on deposits as well as dividends on an accrual basis. The planned consumption level only deviates from the actual level $c_{h,t}$ in the case in which h cannot afford to consume $c_{h,t}^p$ due to the lack of money or it is not able to do so due to a lack of goods supply. The HH's sources of income include a mix of wages and unemployment benefits depending on how long it was unemployed until t as well as interest on its deposits. Moreover, at the end of each fiscal year, firms and banks (partially) distribute their profits in form of dividends to HHs.

Firms use the generated revenues to pay wages and, if any, to settle due parts of their obligations from loan contracts, i.e. they make principal payments and pay interest to the bank. If a firm is not able to meet its debt obligations, it exits the market and all financial claims are cleared in such a way that banks have to depreciate the outstanding loans after receiving the proceeds of the liquidation of the firm's assets, if any, and owners (HH) lose their share of the firm's equity. Moreover, all employees loose their jobs. Assuming that the bankruptcy of a firm happened in period t , a new firm enters the market in $t + 24 + \varrho$ (where ϱ is a positive uniformly distributed integer between zero and 48) given that there exists a sufficiently large group of investors.²¹ If all goes well and the firm meets its obligations until the end of the fiscal year, it determines the profit before taxation

$$\Pi_{f,t}^{bt} = s_f \cdot p_f - \left(i_f^{debt} + \Psi_f w_f \right) \quad (11)$$

where the cost of goods sold include due interest on outstanding debt i_f^{debt} and labor costs of the fiscal year (for a detailed description of interest rates charged on loans, see section 3.6). In

²⁰One unit represents a whole bundle of goods in order to also be able to consume continuous instead of just discrete values of goods.

²¹Firms which are shut down, do not vanish from the economy. In order to ensure the stock-flow consistency of the model, these firms are just inactive until a new group of HH (investors) has enough capital for reactivation [Dawid et al. (2014)].

the case of $\Pi_{f,t} > 0$, firms are burdened by the government with a corporate tax so that the profit after tax results from

$$\Pi_{f,t}^{at} = (1 - \tau^C) \Pi_{f,t}^{bt} \quad (\text{with } \tau^C = 0.6). \quad (12)$$

From the remaining profit after taxation, $\theta \Pi_{f,t}^{at}$ serves as retained earnings to strengthen the internal financing capacity while the residual of $(1 - \theta) \Pi_{f,t}^{at}$ (with $\theta = 0.9$) is distributed as dividends to equity holders.

3.6 Credit Market and Interest Environment

Firms in need of external financing send a credit request to a (traditional) bank which then decides on the interest to charge on the loan. The interest depends on the firm's ability to generate sufficient cash flow during the past fiscal year in order to meet its potential future debt obligations.²² Now firms can evaluate on the profitability of the investment given the offered loan conditions. This decision is based on the internal rate of return which is represented by the fact that the firm's probability to take the loan ($\mathcal{L}_{f,t}$) under the offered conditions negatively depends on the offered interest rate $i_{b,f,t}$, i.e.

$$\Pr(\mathcal{L}_{f,t} \mid i_{b,f,t}) = \max[1.8 - 7.5i_{b,f,t}, 0]. \quad (13)$$

Hence, there might be cases in which the added risk premium is so high (due to the inadequacy of the firm's latest cash flow statement) that it decides to refuse the loan offer. If a firm is credit rationed for this or any other reason²³ by a traditional bank, it tries to finance its planned production with funds from the shadow banking sector which is able to offer more attractive loan conditions than the regulated banking system.²⁴ Moreover, shadow banks have less incentives to ensure high quality underwriting standards because they do not hold their originated loans after its securitization. If the firm is not even able to acquire the needed funds from shadow banks, it can only employ an amount of workers appropriate to its internal financing capacity.

In addition to the liquidity provision to the real sector, traditional banks have also other opportunities to generate profits. In general, they do so by exploiting the prevailing interest spreads. We want to give a more intuitive picture of the interest environment into which agents are embedded by means of [Figure 8](#). The shown spreads form an incentive scheme for the banking sector that determines what to do with its lending capacity, i.e. since $i_{t,B}^{Loan} > i_{t,CB}^T > i_{t,CB}^{OSDF}$ holds, meeting the real sector's demand for credit has the highest priority whereas lending excess reserves to peers or placing them at the CB are subordinated.²⁵ Hence, the larger the spread between the interest paid on deposits ($i_{t,B}^{Deposits}$) and the interest charged on loans

²²There is also the possibility of only *partially* granting the requested loan, but following a survey of the ECB, these cases are only of minor importance. The decision process used here represents over 80% of decisions made by banks within the Euro area [[ECB \(2010\)](#)]. The decision process of banks concerning the granting of loans is described in detail in [subsection 3.6](#).

²³Traditional banks may reject a loan request directly without evaluation of the firm's ability to create sufficient cash flows to repay the funds because of regulatory requirements.

²⁴This is in line with empirical observations, since the unregulated part of the financial system exhibits much more flexibility compared to the traditional banking system facing increasing competitiveness instead [[Hoenig \(1996\)](#)].

²⁵A monetary framework with such an incentive scheme at its heart may have pitfalls. The recent past has shown that the European Central Bank's power to encourage the lending activity to the real sector in a low-interest environment (near the ZLB) is limited as the ECB actually wasn't able to force banks to use the provided liquidity for loans to the real sector even by charging instead of paying interest on excess reserves deposited at the central bank, i.e. $i_{t,CB}^{OSDF} < 0$ instead of $i_{t,CB}^{OSDF} > 0$.

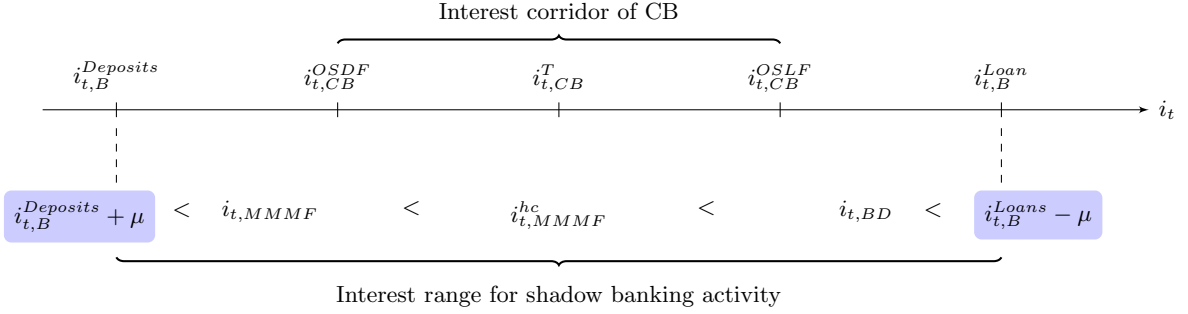


Figure 8: Interest spreads on the credit/money market

($i_{t,B}^{Loan}$) is, the more profitable is the traditional banking business. However, as a side-effect, this profit-maximizing behavior of traditional *universal* banks creates huge incentives for alternative forms of financial intermediaries to enter the market. Since shadow banking mimics traditional financial intermediation by providing every of the several services of the intermediation process through an independent, unregulated and highly specialized financial entity instead of providing the whole range of financial services by a single institution, they can do it at much lower costs²⁶ and, thus, are able to operate in a much more flexible business environment. As a consequence, the profit potential and the incentive to compete with universal banks for market share is huge which can be seen as an explanation for the boom in the shadow banking activity during the last two decades.

Hence, to complete the described incentive scheme for the traditional banks, we have to implement a corresponding scheme for shadow banks in a consistent way. Thus, assuming even similar operating costs, they make profit as long as their whole lending process includes an interest spread ranging between $i_{i,B}^{Deposits} + \mu$ and $i_{i,B}^{Loans} - \mu$ with $\mu > 0$. In order to attract funds from investors, shadow banks must pay a higher interest compared to the interest on deposits paid by traditional banks, i.e. $i_{i,B}^{Deposits} + \mu$. At the same time, the interest charged on loans should be marginally lower than the rates charged by traditional banks to attract credit demand from the real sector, i.e. $i_{i,B}^{Loans} - \mu$. Since the modeled shadow banking process consists of two entities, the rates charged on each other for their specific services must also fall into this spread, i.e. the rate charged by the MMF for the (overnight) repo with the broker-dealer (haircut) must exceed the interest paid to investors. Accordingly, the interest charged by the broker-dealer on the loans must be lower than that of traditional banks but also higher than the haircut paid to the MMF for the repo.

3.7 Foundation and Bankruptcy

The initial bilateral relationships between financial and real sector agents are assigned randomly, i.e. each household and firm chooses a traditional/shadow bank where it places its deposits, requests loans or decides to place investments. These relationships do only change in the case of a default of an agent.

In general, there are two underlying causes for defaults of real and financial sector agents in

²⁶Due to the fact that shadow banks do not have to comply with regulatory requirements concerning their balance sheet structure, the types of asset classes they hold or their level of leverage, they are highly attractive because they usually are able to accomplish a much higher ROE since they make profits on a much smaller capital base, at least, as long markets are liquid and the sensitivity to risk is low due to a euphoric market sentiment.

the economy, i.e. illiquidity and insolvency. For instance, if a firm does not have sufficient funds to pay wages or it is not able to meet its debt obligations, it defaults due to illiquidity. Especially shadow banks face a significant liquidity risk due to the highly pro-cyclical and fragile character of their funding sources and the missing link to a liquidity backstop. Moreover, at the end of each settlement period, agents compute their profits, and update their income statements and balance sheets in order to determine their individual period obligations concerning debt financing, taxes and dividends. After these assessments, agents might conclude that the revenues of the last couple of periods might have been sufficiently low and that, as a consequence, the net worth has turned negative, i.e. the agent has to declare its default due to insolvency. In either case, the malfunction leads to a shut down of the firm’s operating business entailing the resolution of all its economic relationships and commitments as well as its final liquidation.

In the case of a threatening default of a systemically important bank (SIB), i.e. of a bank that has significant market share²⁷ and, thus, a crucial role for the functioning of the payment system, the government bails out the institution in distress by issuing new government bonds and waiving of deposits in order to provide the needed capital. In turn, the government becomes a shareholder of the bailed out bank and tries to sell its shares to investors in future periods. In the case of a default of a (sufficiently small) bank, all clients of the insolvent bank randomly choose a new bank and if a new founded bank enters the market, clients of other banks have a small probability to switch. New firms also form their bank relationships randomly.

3.8 Financial Regulation

The financial supervisory authority agent aims to ensure the growth-supportive capacity of the financial sector by imposing micro- and macroprudential capital requirements on traditional banks according to the Basel III accord [Krug et al. (2015)] while the shadow banking sector does not face any regulatory requirements at all.²⁸ Hence, traditional banks have to comply simultaneously with the risk-sensitive measures of

- a core capital ratio of 4.5%
- that is extended by the capital conservation buffer (CConB) of 2.5% and
- a counter-cyclical buffer (CCycB) of 2.5% which is set by the CB according to the rule described in [Basel Committee on Banking Supervision \(BCBS\) \(2010\)](#); [Drehmann and Tsatsaronis \(2014\)](#); [Agénor et al. \(2013\)](#); [Drehmann et al. \(2010\)](#),²⁹

²⁷For simplicity, the market share of a bank is approximated by its size in terms of total assets. The threshold for a bank being classified as systemically important is set at the inverse of the number of banks meaning that an insolvent bank lying above that threshold is bailed out since it represents a significant part of the payment system. As a result, the probability for banks to be bailed out by the government increases with the bank defaults that already happened. For five banks, this would be 20%.

²⁸We do not explicitly modeled Basel III’s liquidity requirements (LCR and NSFR), since the literature identifies the capital regulation as the most effective. For further analysis on the relationship between banks’ liquidity regulation and monetary policy, see e.g. [Scheubel and K rding \(2013\)](#). For an overview on the effort to implement macroprudential policy in the EU see [Gualandri and Noera \(2015\)](#).

²⁹

$$CCycB_{t+1} = [(\Lambda_t - \Lambda_t^n) - N] \cdot \frac{2.5}{M - N}$$

with the credit-to-GDP ratio

$$\Lambda_t = \frac{C_t}{GDP_t}.$$

In line with the regulatory proposal of the Bank of International Settlement (BIS), we set $N = 2$ and $M = 10$.

- surcharges on systemically important banks (SIB) using the banks' market share as an indicator as well as
- a (non-risk sensitive) leverage ratio of 3%.

The risk-sensitive measures require a minimum amount of capital in relation to the banks' exposure to (credit) risk, i.e. a fraction of its risk-weighted assets (RWA). The contribution of a loan to a banks' $RWA_{b,t}$ depends on the idiosyncratic probability of default of the borrower. Thus, the RWA are an increasing function of the borrower's D/E-ratio, i.e.

$$PD_{j,t} = 1 - \exp\{-\rho_j \xi_{j,t}\} \quad \text{with } j \in \{f, b\}, \rho_j \in \{0.1, 0.35\} \quad (14)$$

for claims against firms ($j = f$) and banks ($j = b$), respectively. The qualitative differences concerning the business models of firms and banks, lead to the fact that the latter can have a much higher D/E-ratio for the same risk weight compared to firms. Positive risk weights are assigned to assets resulting from loan contracts whereas government bonds have a zero-risk weight.

3.9 Monetary Policy

Since we have described how the CB uses the target rate as key instrument to transmit monetary policy in the model (subsection 3.3), we finally have to explain how decisions about its current level are made. The CB follows a standard Taylor Rule under flexible inflation targeting in order to ensure price and output stability:

$$i_t^* = i^r + \pi^* + \delta_\pi(\pi_t - \pi^*) + \delta_x(x_t - x_t^n) \quad (15)$$

with $i^r = \pi^* = 0.02$ and x_t^n representing the long-term trend of real GDP measured by application of the Hodrick-Prescott-filter (with $\lambda = 1600/4^4 = 6.25$ for yearly data [Ravn and Uhlig (2002)]).

The scheme's inherent interest incentive for banks combined with being in full control of the target rate and, thus, of the prevailing interest corridor, enables the CB to perfectly steer interest rates, indebtedness of the real sector and, hence, economic activity.

4 Design of Experiments (DOE)

The technical implementation of the experiments can be outlined as follows. In order to shed light on the question if and how shadow banking activity should be restricted by financial regulation, the performance of various cases (scenarios) is evaluated in counterfactual simulations of the underlying agent-based (disequilibrium) macroeconomic model.³⁰ Therefore, we conduct Monte Carlo simulations for random seeds $1, \dots, 1000$ while every run has a duration of $T = 3000$ periods and the chosen set up consists of 125 HH, 25 firms, 5 banks as well as 5 MMFs and Broker-dealers. According to our setting,³¹ this duration can be translated into approx. 60 years. Hence, for the analysis, we take the last 50 years (2400 periods) into account and use the first 600 periods as initialization phase.

³⁰ The extended ACE model is programmed in Scala 2.11.8 and the code is available upon request to s.krug@economics.uni-kiel.de.

³¹ Within our model, every tick represents a week and every month has 4 weeks which adds up to 48 weeks for an experimental year.

Within the previously explained model framework, we analyze the different outcomes of six scenarios which aim to represent the economy’s development concerning the balancing of financialization and appropriate regulation. Hence, these scenarios are modeled in such a way that they represent states of the economy ranging from past ones (no shadow banking activity) over current ones (unregulated shadow banking sector) to some possible future states in which shadow banks also have to comply with regulatory requirements. In the following, we describe the scenarios in more detail:

Case A This scenario represents the baseline or benchmark case in which an entirely institution-based credit system prevails, i.e. only traditional and regulated (universal) banks exist. This means that there is no shadow banking activity at all and the real sector is credit rationed when the conditions offered by traditional banks as main source of liquidity lies outside the acceptable range of the requesting agent. Traditional banks have to comply with the Basel III accord and, thus, might not be able to offer suitable conditions due to their current balance sheet structure. A detailed description of the model’s baseline version including a section on its validation can be found in [Krug \(2015\)](#).

Case B In a first extending step, shadow bank activity is introduced to the baseline scenario as we have it these days, meaning that traditional banks are still regulated while shadow banks are not. This step mimics the recent development towards a market-based credit intermediation system. Here, shadow banks serve as alternative and attractive source of liquidity. As a consequence, they can exploit their advantageous business environment to compete with traditional banks on the credit market and eventually crowd them out to a significant extend. The superior flexibility in terms of their balance sheet structure and their ability to provide low cost credit to the real sector let them gain market share but is also accompanied by increased systemic risk. This scenario can be seen as a good approximation of the current situation.

Case C An inherent part of the current debate about financial regulation relates to a fundamental reform of the way the requirements apply. The invocation to replace the current approach of a “*regulation by institutional form*” with a “*regulation by function*” moves more and more into the spotlight [[Pozsar et al. \(2010\)](#); [Blinder \(2010\)](#); [Vento and Ganga \(2013\)](#)]. Within our experimental lab, this means to make the transition from a regulatory framework that is only applicable to banks (from a legal point of view, shadow banks are not banks) and to proceed with one that regulates financial institutions by their functions, i.e. whether their business model includes credit/liquidity/maturity transformation or not. Thus, in case C, we start experimenting with the regulation of the shadow banking sector by burdening the so far unregulated part of the financial system to likewise comply with the Basel III accord in order to test whether a restriction of extremely leveraged entities would be sufficient to stabilize the economy to the desired extend. This means that, in this case, shadow banks are *equally* regulated compared to traditional banks which reduces the competitive advantage of shadow banks substantially. Moreover, in this scenario only traditional banks have access to central bank liquidity, i.e. there is no lender of last resort for shadow banks.

Case D Case D goes one step further by regulating the shadow banking sector even *stricter* than traditional banks. Here, we just tighten the requirements of the Basel III accord, i.e. the *capital adequacy ratio* for shadow banks is now 10% while it remains at 4.5% for traditional banks. The complementary risk-based requirement of *surcharges for systemically important financial institutions* (SIFI) is doubled leaving the process of assigning

the institutions into the buckets stays untouched. An equivalent change is implemented for the non-risk sensitive *leverage ratio* which rises from 3% to 10% for shadow banks. Moreover, there is still no access to central bank liquidity for shadow banks.

Case E Mehrling (2012) (among others) questions the sufficiency of the public safety net’s liquidity backstop because it is exclusively accessible for traditional banks. This criticism cause us to additionally analyze cases in which the now regulated shadow banking sector not only faces the downside of financial regulation but also has access to a lender of last resort. In order to isolate the effect on the stability of the system, case E is equivalent to case C except for the this detail. Hence, both traditional and shadow banks are equally regulated and, this time, solvent but illiquid institutions of both sectors have access to central bank liquidity.

Case F Case F is the corresponding equivalent to Case D, i.e. with the described tighter regulation of shadow banks but now with additional access to central bank liquidity.

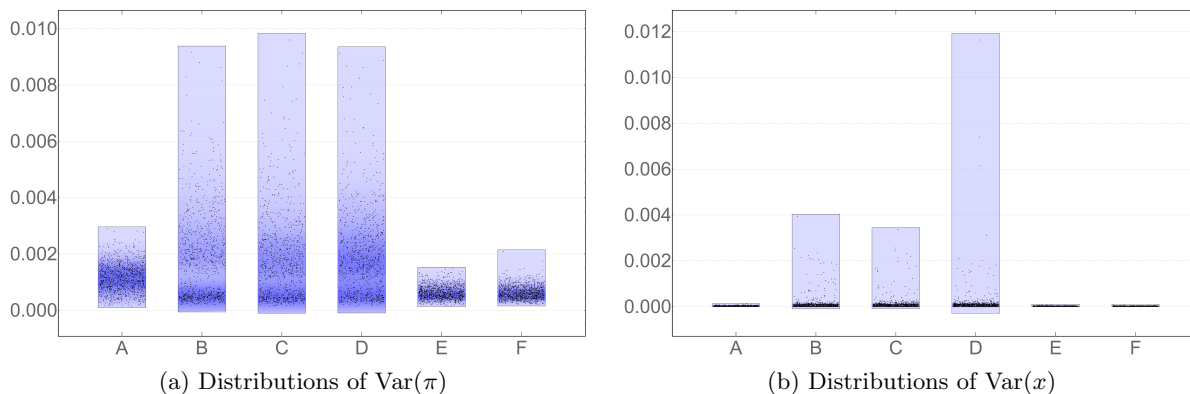


Figure 9: Results for central bank’s dual mandate

5 Discussion of Results

5.1 Macroeconomic Stability

We start the presentation of the simulation results³² with a closer look at the standard parts of a central bank’s loss function operating within a flexible inflation targeting regime, i.e. the variances of inflation π and output x . Table 2 shows the results for the different experiments and we see that the system without shadow banking activity (case A) endows the monetary policy makers with much more control to steer the economy onto a rather calm trajectory. When the economy passes through the transition towards a mainly market-based credit system by introducing (unregulated) shadow banks, this changes dramatically and volatilities rise significantly. Such a parallel banking system, i.e. completely beyond the reach of regulators, seems to negatively affect the central bank’s ability to achieve their policy goals as the occurrence of the recent

³²Our results are robust in the sense that they do not alter qualitatively under different setups of the experiments. We conducted the same simulations either with significantly more agents following Riccetti et al. (2014) (i.e. 500 households, 80 firms and 10 banks), and we also varied the size of the shadow banking sector relative to the traditional banking sector. Concerning the latter experiments, we simulated both a much smaller (larger) shadow banking sector being half (twice) as large as the traditional one.

Table 2: Macroeconomic stability

Case	Var(π)	Var(x)
A	0.00116132 (100.00%)	0.0000231731 (100.00%)
B	0.00183051 (157.63%)	0.0001404550 (606.11%)
C	0.00178202 (153.45%)	0.0001050580 (453.36%)
D	0.00189498 (163.18%)	0.0001355790 (585.07%)
E	0.00063002 (54.25%)	0.0000156398 (67.49%)
F	0.00062860 (54.13%)	0.0000157170 (67.83%)

global financial crises has harmfully shown. If the activity of this disrupting element would be restricted by incorporating shadow banks into the regulatory framework, this does not change much (case C) and the variance of inflation and output decline just slightly. Constraining the lending activity of shadow banks over-proportionally and trying to enhance the competitiveness of traditional banks through massive regulation, in turn, worsens the situation from a central bank's point of view. Note that until now, the incorporation of shadow banks into the regulatory framework is incomplete since they are burdened with financial regulation but still haven't access to a lender of last resort. This brings us to the results for case E and F, which suggest that the volatilities seem to be driven by the absence of the liquidity insurance of the central bank. The huge liquidity risk underlying the shadow banks' fragile funding model can be eliminated to a large extent if they would have also access to public safety net in return for their regulatory burden. Figure 9a and 9b show the distributions of the variances of inflation and of the output gap, respectively, in detail.

5.2 Economic Growth

The most fundamental dimension of interest concerning the impact of varying degrees of financialization is, of course, economic growth. Table 3 shows the average annual growth rates in both nominal and real terms. Although, on a bird's eye view, one would think that the different scenarios only have minor effects on growth, the reader should note that these are average growth rates per year over a time span of 50 years. So even rather small deviations from the benchmark case A mean significant deviations in the growth-path over the whole simulated period of time.

Table 3: Average annual growth rates (nominal/real)

Case	Avg. nominal growth (% p.a.)	Avg. real growth (% p.a.)
A	3.35398 (100.00%)	1.25396 (100.00%)
B	3.60575 (107.51%)	1.28218 (102.25%)
C	3.56649 (106.34%)	1.26385 (100.79%)
D	3.58598 (106.92%)	1.29978 (103.65%)
E	3.58371 (106.85%)	1.09079 (86.99%)
F	3.58683 (106.94%)	1.09223 (87.10%)

In nominal terms, the presence of alternative sources of liquidity seems to have (at least on average) an overall positive impact on growth, independent from the regulatory dimension. This is different for average real growth rates, since they drop when shadow banks have access to a lender of last resort while they show a moderate increase without. As we show in figure

10b, this phenomenon mainly stems from the fact that the volatility of real annual growth rates declines substantially in systems in which all institutions involved in the financial intermediation process are both subject to financial regulation (limiting systemic risk through the reduction of insolvency risk) and have a liquidity backstop (limiting the liquidity risk). Whereas leaving parts of the financial system completely unregulated (case B) can lead to strongly negative and harmful average growth rates. Despite the rarity of these events, policy makers definitely would choose to avoid such states in advance if they would be able to do so. Thus, our results show that the mitigation of systemic risk in as much dimensions as possible is directly linked to the *most stable*, although not growth-maximizing, trajectories of real growth, i.e. to preferred states from a central bank’s point of view. This highlights the common trade-off between the primal (stability) goals of the central bank and the maximization of economic growth which can be typically found in this regard.

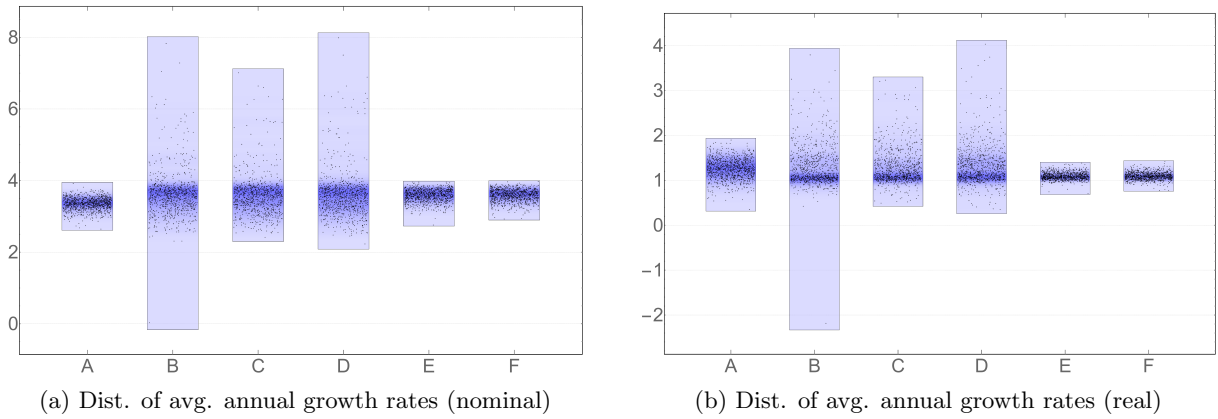


Figure 10: Distributions of mean annual growth rates

5.3 Financial Sector Stability

As we know from the recent past, a resilient financial system can be seen as a prerequisite for the achievement of primary monetary policy goals [Blanchard et al. (2010, 2013); Schularick and Taylor (2012)]. Hence, it might be worthwhile to have a closer look at the development of some financial stability-related variables to get a better idea of what drives the results of section 5.1. Table 4 shows the default rates of financial sector agents across the experiments.

Table 4: Average default rates of financial sector agents

Case	trad. Bank	# bail outs	MMF	Broker-dealer	fiscal costs (in mio.)
A	63.8990 (100.00%)	26.1160 (100.00%)	–	–	326.442 (100.00%)
B	77.7692 (121.71%)	21.9990 (84.24%)	2.43623 (100.00%)	62.7257 (100.00%)	310.154 (95.01%)
C	75.4374 (118.06%)	21.9550 (84.07%)	3.51351 (144.22%)	13.9319 (22.21%)	308.129 (94.39%)
D	76.4724 (119.68%)	22.8372 (87.45%)	3.88844 (159.61%)	14.7930 (21.99%)	335.170 (102.67%)
E	81.5373 (127.60%)	18.6139 (71.27%)	1.09353 (44.89%)	0.0000 (0.00%)	118.879 (36.42%)
F	82.3736 (128.91%)	18.0819 (69.24%)	1.08691 (44.61%)	0.0000 (0.00%)	117.688 (36.05%)

The data on defaults of traditional banks reflects the increased competitiveness on the credit market due to the presence of shadow banks since more banks fail and even the expansion of the regulatory framework does not lead to a reversing effect. But one also has to incorporate the

number of government bail outs through the course of the simulations which show an opposite development. Considering both variables, the data suggests that traditional banks do not fail more often but they lose in market share which makes them less systemically important and the government less often decides to jump in and to bail out the institution in distress.³³ Instead, it lets the bank fail and resolves it. Thus, although traditional banks are not regulated differently across the experiments, the regulation of shadow banks and the accompanied loss in market share due to the increased competitiveness on financial markets might lead to a mitigation of the moral hazard problem related to the “too-big-to-fail”-state of financial institutions. Moreover, our results show clearly that in the case of a regulation of shadow banks, in whatever form, the supervisory authorities have to take into account possible externalities on the already regulated part of the financial system although the regulation imposed on it does not change. Finally, the fiscal costs arising from government bail outs of banks decline tremendously when shadow banks are linked to the public safety net.

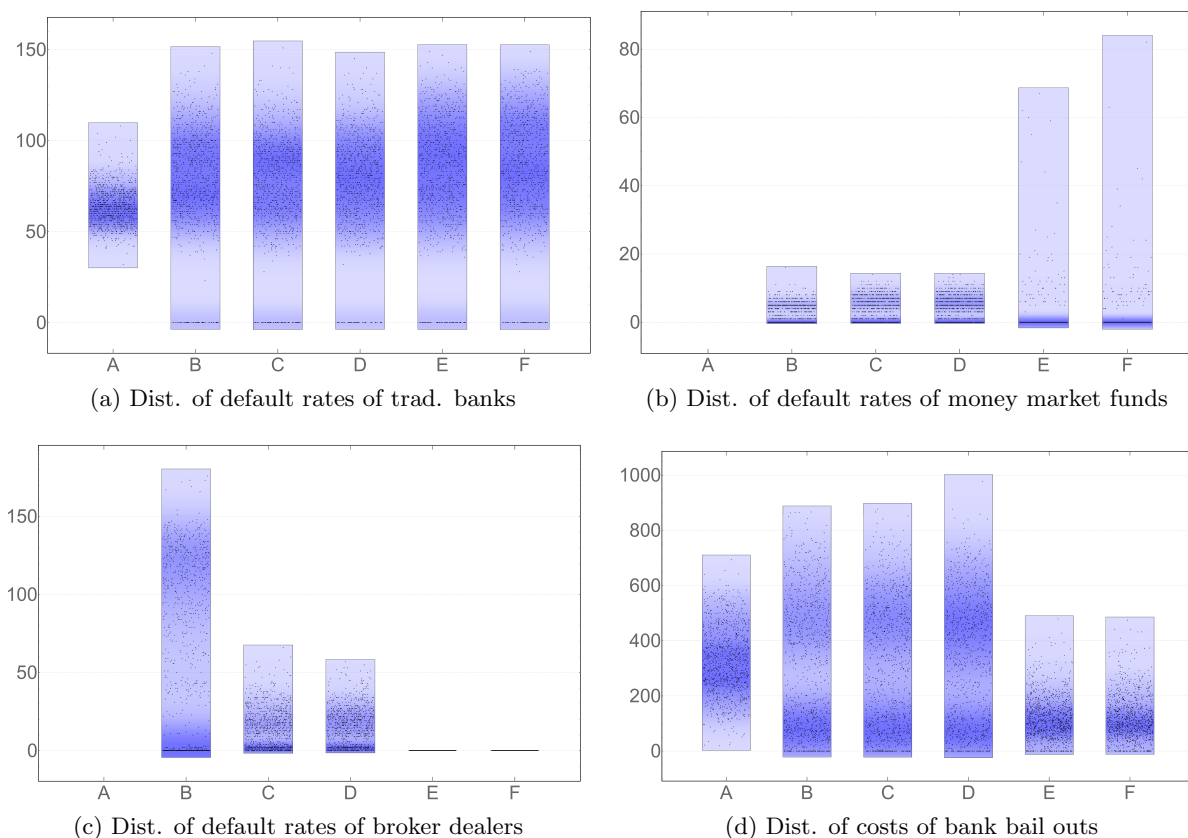


Figure 11: Distributions of financial sector agent default rates and fiscal costs

In addition to table 4, figure 11c emphasizes the relevance of restricting the balance sheet structure and the leverage of shadow banks by regulation. The average default rates, especially of Broker-dealer, decrease strongly and even drop to some tail events if liquidity and overall

³³We do not implement the opportunity to bail out shadow banks, although the recent past has shown that this is, indeed, a quite realistic scenario. The reason is that the bail out of AIG was necessary because it was directly linked to the banking system meaning that its default would indirectly affect the payment system by bringing traditional banks in financial distress. In our model, this direct link is not present and without it, the default of a shadow bank affects economic activity but not the functioning of the payment system.

market risk is reduced by the central banks' liquidity insurance. For MMF, the effect is different, since their business model is indirectly affected by the restriction of the Broker-dealer's lending flexibility and they sometimes get in trouble due to the lack of investment opportunities and profit (see figure 11b).³⁴

Table 5: Average variance in credit-to-GDP gap across cases

Case	Var(credit-to-GDP gap)
A	0.0241032 (100.00%)
B	0.1283510 (532.51%)
C	0.1054290 (437.41%)
D	0.0816890 (338.91%)
E	0.0178757 (74.16%)
F	0.0179898 (74.64%)

To underpin the results of this section, we also have a look at the volatility in the credit-to-GDP gap ($\Lambda_t - \Lambda_t^n$) serving as a common early warning indicator for excessive and unsustainable credit growth and, thus, for financial crises [Drehmann and Tsatsaronis (2014); Giese et al. (2014)]. Table 5 shows that the variance in this indicator explodes due to the existence of an unregulated sources of liquidity (case B) and that it can be mitigated to some extent via regulatory requirements but still remains very high relative to the benchmark case (case C and D). The remarkable decline for the cases with a full inclusion of shadow banking activity into the regulatory framework can be explained by much more stable average growth paths (see figure 10b).

5.4 The Credit Market

Our findings concerning the credit market meet the expectations of the literature in the sense that it clearly shows that shadow banking activity is not a bad thing per se [Dombret (2013a,b, 2014a)] but, by analogy with traditional banking of the 19th century [Adrian and Ashcraft (2012a)], it leads to negative externalities and, hence, has to be supervised properly [Pozsar (2014); Meeks et al. (2014); Pozsar et al. (2010)]. Table 6 reveals that the demand for liquidity could better be met with shadow banking activity and the indebtedness of the real sector rises accordingly. Unfortunately, the average default rate of firms (figure 12a) also increases due to the lack of proper regulation of private money creation. The free lending to the real sector including its financial unsound part, i.e to speculative and Ponzi financed firms in Minskyan terms,³⁵ leads to a widened set of possible growth paths (see figure 10a and 10b) and burdening shadow banks with regulatory requirements has a stabilizing effect in this regard by decreasing the average overall indebtedness of the real sector (case D). The most interesting results here are definitely delivered by the cases with full inclusion of shadow banking into the regulatory framework (case

³⁴This is comparable with the current low or negative interest environment which has a similar effect on institutions with a business model based on returns on safe assets. For instance, home loans banks have serious problems to pay the contractually defined interest on deposits due to the lack of investment opportunities which yield a sufficiently safe and high return.

³⁵Note, that the existence of broker dealers by itself also affects the prevailing shares of Minskyan financing schemes in the economy towards speculative ones, since it might be *solvent* enough to buy back the underlying collateral of a repo but usually not *liquid* enough and, hence, likewise contributing to systemic risk through two separate channels, i.e. its own highly leveraged and fragile balance sheet structure and the build up of financial sector imbalances as a result of its lending activity.

E and F). In these cases the default rate of firms declines to the level of an economy without shadow banking activity although much more liquidity is provided and the indebtedness of the real sector exceeds the debt of the benchmark case by far (figure 12b). These credit market data manifest in tremendously stable growth paths which suggests that a full inclusion of the shadow banking sector into the regulatory framework could indeed, from a theoretical point of view, lead to a significant mitigation of the negative externalities accompanied by their fragile funding model and to a suitable exploitation of their liquidity provision capacity in terms of sustainable growth.

Table 6: Credit market data

Case	Avg. firm default rate	Avg. Firm Sector Demand for Credit (in mio.)	Avg. Firm Sector Debt (in mio.)
A	235.066 (100.00%)	494.582 (100.00%)	27.0044 (100.00%)
B	350.224 (148.99%)	123.074 (24.88%)	119.0050 (440.69%)
C	347.334 (147.76%)	124.342 (25.14%)	119.6300 (443.00%)
D	364.421 (155.03%)	128.818 (26.05%)	114.4270 (423.74%)
E	231.348 (98.42%)	103.119 (20.85%)	165.5840 (613.17%)
F	230.666 (98.13%)	102.681 (20.76%)	165.6510 (613.42%)

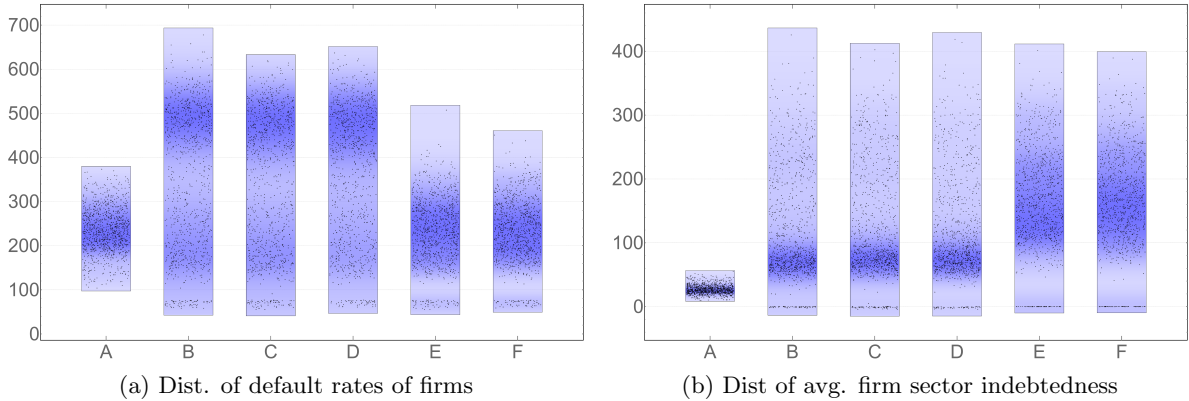


Figure 12: Distribution of credit market related data

To summarize the results, we adopt the approach of Krug (2015) by using a combination of two loss functions to be able to compare the performance across cases. Hence, we define two loss functions concerning *(macro)economic* (L_k^{MS}) and *financial stability* (L_k^{FS}) in order to easily evaluate outcomes in both dimensions whereby the former is usually defined as the weighted sum of the variances of inflation, output gap and of nominal interest rate changes, i.e.

$$L_k^{MS} = \alpha_\pi \overline{\text{Var}(\pi_k)} + \alpha_x \overline{\text{Var}(x_k)} + \alpha_i \overline{\text{Var}(i_k)} \quad (16)$$

with $\alpha_\pi = 1.0$, $\alpha_x = 0.5$, $\alpha_i = 0.1$ [Agénor et al. (2013); Agénor and Pereira da Silva (2012)]. The latter, however, addressing financial stability is defined in terms of the weighted sum of the average burden for the public sector of a bank bailout measured as the fraction of the average bailout costs for the government and the average amount of bailouts, as well as the average amount of bank and firm defaults ($\overline{\zeta_k}$, $\overline{\rho_k}$ and $\overline{\gamma_k}$, respectively), i.e.

$$L_k^{FS} = \alpha^{FS} (\overline{\zeta_k} + \overline{\rho_k} + \overline{\gamma_k}) \quad (17)$$

with $\alpha^{FS} = 0.01$ and $k \in \{A, B, C, D, E, F\}$. The combined loss L is expressed as

$$L = \alpha_L L_k^{MS} + (1 - \alpha_L) L_k^{FS}. \quad (18)$$

Table 7 shows the corresponding losses for each of the considered cases. The results make clear that when taking macroeconomic and financial stability issues into account (with $\alpha_L = 0.5$), the effort to fully include shadow banking activity into the regulatory framework seems to be worthwhile since the loss is much less even when compared to a situation in which traditional banking dominates. In contrast, a pure restriction of alternative activities in the financial sector leads to the highest losses across all scenarios.

Table 7: Combined losses for equally weighted objectives

Case	A	B	C	D	E	F
L	3.25823	3.80171	3.76522	3.99551	2.25223	2.24439

6 Concluding Remarks

The aim of this paper is to shed some light on the transition the credit system has been through over the last decades and on the destabilizing externalities accompanied by this, in particular, the substantial shift in market risks faced by financial institutions that is now much more in the focus of regulators. Aggravating this situation, the permanent seek of market participants for regulatory arbitrage has led to the continuous build up of a parallel and unregulated banking system “*in the shadows*”, i.e. beyond the reach of regulators, which roughly equals the traditional banking system in size.³⁶ Unfortunately, shadow banking does not only reduce the costs of the financial intermediation process but exhibits an extensive contribution to systemic risk due to

- the lack of regulation,
- the lack of access to a public safety net (liquidity and roll over risk) as well as
- the reliance on extreme short-term funding sources (through the money market).

Our contribution is to get some insights into the effects of an inclusion of the shadow banking sector into the current regulatory framework on economic activity and whether such a proceeding would be suitable to internalize the described destabilizing externalities.

As a framework for the analysis, we present an agent-based macro-model with heterogeneous interacting agents and endogenous money. The central bank agent plays a particular role since it controls market interest rates via monetary policy decisions which, in turn, affect credit demand and overall economic activity. Moreover, the model is augmented by a shadow banking sector representing an alternative investment opportunity for the real sector which is characterized by animal spirit-like, i.e. highly pro-cyclical and myopic, behavior in its investment decision. Therefore, we think that the presented model is well suited to analyze the research question at hand since pro-cyclical behavior as well as sudden and common withdrawals of invested funds has been identified as one of the root causes of systemic failures of the past.

Our simulation experiments provide three main findings. First, our results suggest that switching the regulatory regime from “*regulation by institutional form*” to a “*regulation by*

³⁶This is true for the US whereas the shadow banking sector accounts for approximately two-thirds of the traditional bank assets in Europe [Financial Stability Board (2014)].

function” meaning the inclusion of shadow banks into the regulatory framework, as proposed by [Mehrling \(2012\)](#), seems to be worthwhile in general terms.

Second, supervisory authorities should do so in a coordinated and complete manner. A unilateral inclusion, i.e. burdening the shadow banking sector with the same regulatory requirements as traditional banks but denying the access to the public safety net leads to inferior outcomes compared to the benchmark case without shadow banking activity and even to the case in which they are not regulated at all. The results of such cases include negative effects on monetary policy goals, significantly increases in the volatility of growth and financial and real sector default rates as well as a higher volatility in the credit-to-GDP gap.

Moreover, experiments with a full and complete inclusion, i.e. with access to a lender of last resort, lead to superior outcomes in terms of the central bank’s dual mandate, economic growth and financial stability suggesting that a full inclusion of the shadow banking sector into the regulatory framework could indeed, from a theoretical point of view, lead to a significant mitigation of the destabilizing externalities accompanied by their fragile funding model and to a suitable exploitation of their liquidity provision capacity in terms of sustainable growth.

Finally, the present paper is useful to understand why the access to central bank liquidity is so important: the main issue here is the extremely short-term funding maturity (typically overnight). The cash pools (MMF) have a huge incentive to minimize their own liquidity risk and to avoid runs by investors since they have promised the on-demand availability of the invested funds but this promise is not appropriately backed by a sufficient amount of capital which, in turn, creates massive roll-over risk for the broker-dealers. In addition, MMFs collectively tend to underestimate the associated risks with the repos they undertake since these are typically secured transactions signaling an alleged lack of risk due to the negligence of interconnectedness and interaction effects of operating on the same markets. This means, that in the case of a broker-dealer default resulting from a refusal to roll over the repo for another night, the MMF systemically neglects the fact that it will be forced to fire sale the collateral in order to serve the withdrawals from its investors. In such a situation, MMFs can only turn to financial markets since they control huge deposit volumes and have no link to a lender of last resort. The associated discount puts additional pressure on the badly capitalized funds triggering even more harmful collective actions. These features of financial crises originating in the shadow banking sector are fully covered by the presented version of our model and our results clearly show the negative effects on economic activity of a lack of contagion-free, alternative sources of liquidity within the shadow banking sector as it is nowadays.

These negative effects can be seen as a typical result of a coordination failure. Socially, it would be better if agents would avoid the negative externalities of their sudden collective withdrawals by appropriate coordination and the distribution of possible (collective) losses across *all* agents. Instead, their behavior is guided by selfishness and the attempt to maximize their individual utility by strictly acting to minimize *individual* losses. This reveals the need for an intervention of a superordinate institution like a financial supervisory authority to internalize negative effects exogenously and to prevent socially undesired states of the system, i.e. financial crises.

For future research, an extension towards the direct link between traditional and shadow banks would incorporate another highly relevant issue with regard to financial stability. In such a scenario, public sector bail outs of systemically important shadow banks would be of much interest. Furthermore, one could also test the performance of other macroprudential tools since the Basel III accord does only include a selection of the available tools which are related to financial institutions. Here, the impact of a loan-to-value ratio (LTV) or a debt-to-income ratio (DTI) applied on household credit could be interesting and it would similarly enable

the researcher to extend the analysis towards the financial cycle. Finally, an extension of the model towards an open economy could also be an interesting task and would widen the range of research questions which can be addressed and analyzed using the underlying agent-based framework significantly.

References

- Adrian, T. and Ashcraft, A. (2012a). Shadow Banking: A Review of the Literature, *Staff Reports no. 580*, Federal Reserve Bank of New York.
- Adrian, T. and Ashcraft, A. (2012b). Shadow Banking Regulation, *Annu. Rev. Financ. Econ.* **4**(1): 99–140.
- Adrian, T. and Boyarchenko, N. (2012). Intermediary Leverage Cycles and Financial Stability, *Federal Reserve Bank of New York Staff Reports no. 567*.
- Adrian, T. and Shin, H. S. (2008). Liquidity, Monetary Policy, and Financial Cycles, *Current Issues in Economics and Finance* **14**(1): 1–7.
- Adrian, T. and Shin, H. S. (2009). The Shadow Banking System: Implications for Financial Regulation, *Federal Reserve Bank of New York Staff Report No. 382*.
- Afonso, G. and Lagos, R. (2013). The Over-the-Counter Theory of the Fed Funds Market: A Primer, *Staff Report no. 660*, Federal Reserve Bank of New York.
URL: http://newyorkfed.org/research/staff_reports/sr660.html
- Agénor, P.-R., Alper, K. and Pereira da Silva, L. A. (2013). Capital Regulation, Monetary Policy, and Financial Stability, *International Journal of Central Banking* **9**(3): 193–238.
- Agénor, P.-R. and Pereira da Silva, L. A. (2012). Macroeconomic Stability, Financial Stability, and Monetary Policy Rules, *International Finance* **15**(2): 205–224.
- Akerlof, G. A. and Shiller, R. J. (2009). *Animal Spirits: How Human Psychology Drives the Economy, and Why It Matters for Global Capitalism*, Princeton University Press, New Jersey.
- Arciero, L., Biancotti, C., D’Aurizio, L. and Impenna, C. (2009). Exploring Agent-based Methods for the Analysis of Payment Systems: A Crisis Model for StarLogo TNG, *Journal of Artificial Societies and Social Simulation* **12**(1): 2.
- Arnold, B., Borio, C., Ellis, L. and Moshirian, F. (2012). Systemic Risk, Macroprudential Policy Frameworks, Monitoring Financial Systems and the Evolution of Capital Adequacy, *Journal of Banking & Finance* **36**(12): 3125 – 3132.
- Aymanns, C. and Farmer, J. D. (2015). The Dynamics of the Leverage Cycle, *Journal of Economic Dynamics and Control* **50**: 155 – 179.
- Bank of England (2014a). Bank of England Settlement Accounts, *Technical report*, Bank of England.
URL: <http://www.bankofengland.co.uk/markets/Documents/paymentsystems/boesettlementaccounts.pdf>
- Bank of England (2014b). The Bank of England’s Sterling Monetary Framework (The Red Book), *Technical report*, Bank of England.
URL: <http://www.bankofengland.co.uk/markets/Pages/sterlingoperations/redbook.aspx>

- Basel Committee on Banking Supervision (BCBS) (2010). Guidance for National Authorities Operating the Countercyclical Capital Buffer, *Technical report*, Bank for International Settlements (BIS).
URL: <http://www.bis.org/publ/bcbs187.htm>
- Battiston, S., Farmer, J. D., Flache, A., Garlaschelli, D., Haldane, A. G., Heesterbeek, H., Hommes, C., Jaeger, C., May, R. and Scheffer, M. (2016). Complexity Theory and Financial Regulation, *Science* **351**(6275): 818–819.
- Bernanke, B. S., Gertler, M. and Gilchrist, S. (1999). The Financial Accelerator in a Quantitative Business Cycle Framework, in J. B. Taylor and M. Woodford (eds), *Handbook of Macroeconomics*, Vol. 1, Part C of *Handbook of Macroeconomics*, Elsevier, chapter 21, pp. 1341 – 1393.
- Blanchard, O. J., Dell’Ariccia, G. and Mauro, P. (2010). Rethinking Macroeconomic Policy, *Journal of Money, Credit and Banking* **42**(s1): 199–215.
- Blanchard, O. J., Dell’Ariccia, G. and Mauro, P. (2013). Rethinking Macro Policy II: Getting Granular, *IMF Staff Discussion Note SDN/13/03* pp. 1–26.
- Blinder, A. S. (2010). Its Broke, Lets Fix It: Rethinking Financial Regulation, *International Journal of Central Banking* **6**(34): 277–330.
- Bookstaber, R. (2012). Using Agent-based Models for Analyzing Threats to Financial Stability, *U.S. Department of the Treasury, Office of Financial Research, Working Paper #0003* .
- Borio, C. (2014). Monetary Policy and Financial Stability: What Role in Prevention and Recovery?, *BIS Working Papers no. 440*, Bank for International Settlements.
- Borio, C. and Zhu, H. (2012). Capital Regulation, Risk-taking and Monetary Policy: A Missing Link in the Transmission Mechanism?, *Journal of Financial Stability* **8**(4): 236 – 251.
- Chernenko, S. and Sunderam, A. (2014). Frictions in Shadow Banking: Evidence from the Lending Behavior of Money Market Mutual Funds, *Review of Financial Studies* **27**(6): 1717–1750.
- Claessens, S., Kose, M. A. and Terrones, M. E. (2012). How Do Business and Financial Cycles Interact?, *Journal of International Economics* **87**(1): 178 – 190.
- Dawid, H., Gemkow, S., Harting, P., van der Hoog, S. and Neugart, M. (2014). The Eurace@Unibi Model: An Agent-based Macroeconomic Model for Economic Policy Analysis, *University of Bielefeld Working Papers in Economics and Management* **2012**(5).
- De Grauwe, P. (2011). Animal Spirits and Monetary Policy, *Economic Theory* **47**(2): 423–457.
- Dent, A. and Dison, W. (2012). The Bank of England’s Real-Time Gross Settlement Infrastructure, *Bank of England Quarterly Bulletin* **2012**(Q3): 234–243.
- di Iasio, G. and Pozsar, Z. (2015). A Model of Shadow Banking: Crises, Central Banks and Regulation, *SSRN Electronic Journal* .
- Dombret, A. (2013a). Systemic Risks of Shadow Banking, Speech at the Salzburg Global Seminar “Out of the Shadows: Should Non-banking Financial Institutions Be Regulated?”, Salzburg, 20 August 2013.

- Dombret, A. (2013b). Systemic risks of shadow banking, Speech held at the Salzburg Global Seminar "Out of the Shadows: Should Non-banking Financial Institutions Be Regulated?", Salzburg, 20th of August, 2013.
URL: <http://www.bis.org/review/r130821a.pdf>
- Dombret, A. (2014a). Financial Market Regulation – Standing Still Means Falling Behind, Speech held at the 2014 Alternative Investor Conference of the Federal Association for Alternative Investments, Frankfurt am Main, 14th of May, 2014.
URL: <https://www.bis.org/review/r140519d.htm>
- Dombret, A. (2014b). Shadow Banking and the Roots of International Cooperation, Speech at a reception to bid farewell to Winfried Liedtke, financial attach, and to welcome his successor, Thomas Notheis, Beijing, 29th of October, 2014.
URL: https://www.bundesbank.de/Redaktion/EN/Reden/2014/2014_10_28_dombret.html?nn=2104
- Drehmann, M., Borio, C., Gambacorta, L., Jiménez, G. and Trucharte, C. (2010). Countercyclical Capital Buffers: Exploring Options, *BIS Working Papers no. 317*, Bank for International Settlements.
- Drehmann, M., Borio, C. and Tsatsaronis, K. (2012). Characterising the Financial Cycle: Don't Lose Sight of the Medium Term!, *BIS Working Papers no. 380*, Bank for International Settlements.
- Drehmann, M. and Tsatsaronis, K. (2014). The Credit-to-GDP Gap and Countercyclical Capital Buffers: Questions and Answers, *BIS Quarterly Review 2014*(March): 55–73.
- ECB (2010). Survey on the Access to Finance of Small and Medium-sized Enterprises in the Euro Area: Second Half of 2009, *Technical report*, European Central Bank.
URL: <https://www.ecb.europa.eu/stats/money/surveys/sme/html/index.en.html>
- Financial Stability Board (2014). Global Shadow Banking Monitoring Report 2014, *Technical report*, Financial Stability Board (FSB).
- Financial Stability Board (2015). Global Shadow Banking Monitoring Report 2015, *Technical report*, Financial Stability Board (FSB).
- Galati, G., Koopman, S. J. and Vlekke, M. (2016). Measuring Financial Cycles in a Model-based Analysis: Empirical Evidence for the United States and the Euro Area, *SSRN Electronic Journal* .
URL: <http://dx.doi.org/10.2139/ssrn.2768697>
- Galbiati, M. and Soramäki, K. (2011). An Agent-based Model of Payment Systems, *Journal of Economic Dynamics and Control* **35**: 859–875.
- Geanakoplos, J. (2009). The Leverage Cycle, *Cowles Foundation Discussion Papers 1715*, Cowles Foundation for Research in Economics, Yale University.
URL: <https://ideas.repec.org/p/cwl/cwldpp/1715.html>
- Gennaioli, N., Shleifer, A. and Vishny, R. (2012). Neglected Risks, Financial Innovation, and Financial Fragility, *Journal of Financial Economics* **104**(3): 452 – 468. Market Institutions, Financial Market Risks and Financial Crisis.

- Gennaioli, N., Shleifer, A. and Vishny, R. W. (2013). A Model of Shadow Banking, *The Journal of Finance* **68**(4): 1331–1363.
- Gerali, A., Neri, S., Sessa, L. and Signoretti, F. M. (2010). Credit and Banking in a DSGE Model of the Euro Area, *Journal of Money, Credit and Banking* **42**: 107–141.
- Gertler, M. and Karadi, P. (2011). A Model of Unconventional Monetary Policy, *Journal of Monetary Economics* **58**(1): 17 – 34.
- Giese, J., Andersen, H., Bush, O., Castro, C., Farag, M. and Kapadia, S. (2014). The Credit-To-GDP Gap And Complementary Indicators For Macroprudential Policy: Evidence From The Uk, *International Journal of Finance & Economics* **19**(1): 25–47.
- Goodhart, C. A., Kashyap, A., Tsomocos, D. and Vardoulakis, A. (2012). Financial Regulation in General Equilibrium, *NBER Working Paper Series, Working Paper no. 17909* .
URL: <http://dx.doi.org/10.3386/w17909>
- Gorton, G. and Metrick, A. (2010). Regulating the Shadow Banking System, *Brookings Papers on Economic Activity* **2010**(2): 261–297.
- Gorton, G. and Metrick, A. (2012a). Securitization, *NBER Working paper Series, Working Paper 18611* .
- Gorton, G. and Metrick, A. (2012b). Securitized Banking and the Run on Repo, *Journal of Financial Economics* **104**(3): 425–451.
- Gorton, G. and Metrick, A. (2013). The Federal Reserve and Panic Prevention: The Roles of Financial Regulation and Lender of Last Resort, *The Journal of Economic Perspectives* **27**(4): 45–64.
- Gualandri, E. and Noera, M. (2015). *Bank Risk, Governance and Regulation*, Palgrave Macmillan UK, London, chapter Towards a Macroprudential Policy in the EU, pp. 182–205.
- Haldane, A. G. and Qvigstad, J. F. (2014). The Evolution of Central Banks – a Practitioner’s Perspective, *Norges Bank Conference "Of the uses of central banks: Lessons from history"*, 4-5 June 2014.
- Hoenig, T. M. (1996). Rethinking Financial Regulation, *Economic Review-Federal Reserve Bank of Kansas City* **81**: 5–14.
- Kelsey, E. and Rickenbach, S. (2014). Enhancing the Resilience of the Bank of England’s Real-Time Gross Settlement Infrastructure, *Bank of England Quarterly Bulletin* **2014**(Q3): 316–320.
- Keynes, J. M. (1936). *General Theory of Employment, Interest and Money*, Cambridge University Press, Cambridge.
- Krug, S. (2015). The Interaction between Monetary and Macroprudential Policy: Should Central Banks "Lean Against the Wind" to Foster Macro-financial Stability?, *Economics Working Papers 2015-08*, Christian-Albrechts-University of Kiel, Department of Economics.
URL: http://www.vwl.uni-kiel.de/EconomicsWorkingPapers/abstract.php?stat_id=192
- Krug, S., Lengnick, M. and Wohltmann, H.-W. (2015). The Impact of Basel III on Financial (In)stability: An Agent-based Credit Network Approach, *Quantitative Finance* **15**(12): 1917–1932.

- Lavoie, M. (2003). A Primer on Endogenous Credit-Money, in L.-P. Rochon and S. Rossi (eds), *Modern Theories of Money: The Nature and Role of Money in Capitalist Economies*, Edward Elgar Publishing Limited, Northampton, pp. 506–543.
- Lengnick, M. and Wohltmann, H.-W. (2016). Optimal Monetary Policy in a New Keynesian Model with Animal Spirits and Financial Markets, *Journal of Economic Dynamics and Control* **64**: 148 – 165.
- Luttrell, D., Rosenblum, H. and Thies, J. (2012). Understanding the Risks Inherent in Shadow Banking: A Primer and Practical Lessons Learned, *Dallas FED Staff Papers* **No. 18**.
- Martin, A., Skeie, D. and von Thadden, E.-L. (2013). Repo Runs, *GESY Discussion Paper No 448*.
- McLeay, M., Radia, A. and Thomas, R. (2014a). Money Creation in the Modern Economy, *Bank of England Quartely Bulletin* **54**(1): 14–27.
- McLeay, M., Radia, A. and Thomas, R. (2014b). Money in the Modern Economy: An Introduction, *Bank of England Quartely Bulletin* **54**(1): 4–13.
- Meeks, R., Nelson, B. and Alessandri, P. (2014). Shadow banks and macroeconomic instability, *Bank of England working papers 487*, Bank of England.
URL: <https://ideas.repec.org/p/boe/boeewp/0487.html>
- Meh, C. A. and Moran, K. (2010). The Role of Bank Capital in the Propagation of Shocks, *Journal of Economic Dynamics and Control* **34**(3): 555 – 576.
- Mehrling, P. (2012). Three Principles for Market-based Credit Regulation, *American Economic Review* **102**(3): 107–112.
- Mehrling, P., Pozsar, Z., Sweeney, J. and Neilson, D. H. (2013). Bagehot was a Shadow Banker: Shadow Banking, Central Banking, and the Future of Global Finance, *SSRN Electronic Journal*.
- Minsky, H. P. (1986). *Stabilizing an Unstable Economy*, New Haven, Yale University Press.
- Montagna, M. (2016). *Systemic Risk in Modern Financial Systems*, PhD thesis, Kiel University, Kiel.
- Nakajima, M. (2011). *Payment System Technologies and Functions: Innovations and Developments*, IGI Global, Hershey.
- Plantin, G. (2014). Shadow Banking and Bank Capital Regulation, *The Review of Financial Studies* **0**(0): 1–30.
- Pozsar, Z. (2014). Shadow Banking: The Money View, *Technical report*.
- Pozsar, Z. (2015). A Macro View of Shadow Banking: Levered Betas and Wholesale Funding in the Context of Secular Stagnation, *SSRN Electronic Journal*.
URL: <http://dx.doi.org/10.2139/ssrn.2558945>
- Pozsar, Z., Adrian, T., Ashcraft, A. and Boesky, H. (2010). Shadow Banking, *Available at SSRN 1640545*.

- Ravn, M. O. and Uhlig, H. (2002). On Adjusting the Hodrick-Prescott Filter for the Frequency of Observations, *Review of Economics and Statistics* **84**(2): 371–376.
- Riccetti, L., Russo, A. and Gallegati, M. (2014). An Agent-based Decentralized Matching Macroeconomic Model, *Journal of Economic Interaction and Coordination* **forthcoming**: 1–28.
URL: <http://link.springer.com/article/10.1007%2Fs11403-014-0130-8#page-1>
- Ricks, M. (2010). Shadow Banking and Financial Regulation, *Columbia Law and Economics Working Paper* (370).
- Rosengren, E. S. (2014). Broker-dealer Finance and Financial Stability. Remarks by Eric S. Rosengren, President and Chief Executive Officer, Federal Reserve Bank of Boston, at the Conference on the Risks of Wholesale Funding sponsored by the Federal Reserve Banks of Boston and New York, New York, New York, August 13, 2014.
URL: <http://EconPapers.repec.org/RePEc:fip:fedbsp:85>
- Ryan-Collins, J., Greenham, T., Werner, R. and Jackson, A. (2012). *Where Does Money Come From? A Guide to the UK Monetary and Banking System*, 2nd edn, The New Economics Foundation, London.
- Scheubel, B. and K rding, J. (2013). Liquidity Regulation, the Central Bank, and the Money Market, *Beitrage zur Jahrestagung des Vereins fur Socialpolitik Wettbewerbspolitik und Regulierung in einer globalen Wirtschaftsordnung - Session Liquidity and Regulation, No. E19-V3*.
- Schularick, M. and Taylor, A. M. (2012). Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises, 1870-2008, *American Economic Review* **102**(2): 1029–61.
URL: <http://www.aeaweb.org/articles.php?doi=10.1257/aer.102.2.1029>
- Schwarcz, S. L. (2012). Regulating Shadow Banking, *Review of Banking and Financial Law* **31**(1).
- Schwarcz, S. L. (2013). Regulating Shadows: Financial Regulation and Responsibility Failure, *Washington and Lee Law Review* (forthcoming).
- Solow, R. M. (1956). A Contribution to the Theory of Economic Growth, *The quarterly journal of economics* pp. 65–94.
- Stolzenburg, U. (2015). The Agent-based Solow Growth Model with Endogenous Business Cycles, *Economics Working Papers 2015-01*, Christian-Albrechts-University of Kiel, Department of Economics.
- Strohsal, T., Proano, C. R. and Wolters, J. (2015a). Characterizing the Financial Cycle - Evidence from a Frequency Domain Analysis, number 21 in *Sonderforschungsbereich 649:  konomisches Risiko*, Wirtschaftswissenschaftliche Fakult t.
- Strohsal, T., Proano, C. R. and Wolters, J. (2015b). How Do Financial Cycles Interact? - Evidence from the US and the UK, number 24 in *Sonderforschungsbereich 649:  konomisches Risiko*, Wirtschaftswissenschaftliche Fakult t.
- Sunderam, A. (2015). Money Creation and the Shadow Banking System, *Review of Financial Studies* **28**(4): 939–977.

- van der Hoog, S. and Dawid, H. (2015). Bubbles, Crashes and the Financial Cycle, *University of Bielefeld Working Papers in Economics and Management* **2015**(1).
- Vento, G. A. and Ganga, P. (2013). *Crisis, Risk and Stability in Financial Markets*, Palgrave Macmillan UK, London, chapter Shadow Banking and Systemic Risk: In Search of Regulatory Solutions, pp. 96–115.
URL: http://dx.doi.org/10.1057/9781137001832_6
- Verona, F., Martins, M. M. F. and Drumond, I. (2013). (Un)anticipated Monetary Policy in a DSGE Model with a Shadow Banking System, *International Journal of Central Banking* **9**(3): 74 – 117.
- Winters, B. (2012). Review of the Bank of England’s Framework for Providing Liquidity to the Banking System, *Report for the court of the bank of england*, Bank of England.