An Empirical SFC Model of Real-Financial Cycles and Balance Sheet Dynamics for the Euro Area*

Preliminary and incomplete work in progress version for FMM 2019 – please do not quote or circulate!

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Abstract

Large and complex financial markets have been an increasing source of concern in regard to sustainable long-term growth and financial stability. The aim of our research is to systematically explore this topic by constructing a novel macroeconomic model which incorporates the endogenous dynamics of the creation, valuation and distribution of financial assets and their repercussions on the real economy. Our model includes complex financial markets and a large shadow banking sector, which enables us to simultaneously address issues concerning economic growth, asset price inflation, pro-cyclical leverage effects, and financial fragility. These phenomena lead to the endogenous rise of business cycles induced by financial markets, which we label 'Kindleberger cycles'. We calibrate the model to recent economic developments in the euro area, accounting for balance sheet dynamics that we obtain from National Annual Sector Accounts (NASA) data and extrapolate with our model. The model will be used to evaluate policy options to foster sustainable long-term economic growth in the euro area on a solid empirical basis.

Keywords: Macroeconomic model, stock-flow consistent, sustainable growth, financial cycles, financial fragility, financial regulation, boundary problem.

JEL Classification Numbers: E12, E17, E32, E44, E61, E63.

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1 Introduction

Developments in the financial sector have been increasingly held responsible for sluggish economic growth in industrial countries, and for creating financial fragility. Empirical evidence suggests that asset price dynamics on financial markets are characterised by a sequence of overappreciation (bubble, bull market) and overdepreciation (bear market after a bubble bursts), hence by "long swings", "boom-bust cycles", or "financial cycles". This phenomenon is most probably related to overtrading in the financial system and, more generally, to an oversized and overcomplex financial sector. Recent economic history demonstrated that the impact of revaluation and devaluation of financial wealth on the real economy is enormous.

In a recent paper, the OECD stated that over-sized and complex financial markets, which are not subject to macro-prudential regulation, can slow down economic growth (Cournède et al., 2015). To a large part, recent asset price bubbles were caused by over-extended lending, see Khalil and Kinsella (2015), often for speculative activity on financial and real estate markets. Financial innovations such as securitisation enabled speculative lending, and increased the return on asset markets and the profitability of financial investment while obscuring risks. Increasing income inequality and unsustainable borrowing in the household sector have exacerbated this problem (Stockhammer, 2015; Kumhof et al., 2015). Simultaneously, financial markets failed to deliver a sufficient amount of productive credit to the real economic sector, see Stockhammer (2004), Werner (2012, 2005). The resulting asset price inflation and positive balance sheet effects have increased the flow of funds into the financial sector due to expected capital gains, inducing a positive feed-back loop within the financial system. Since the financial and economic crisis of 2008/09, debt-repayment and develeraging of households, firms and the financial sector - a 'balance sheet recession' (Koo, 2014) - as well as stagnating real investment continue to weigh on the economy in the Eurozone.

Despite recent developments in the literature and historical evidence of the frequent occurence of financial cycles (see Section 2), most macroeconomic models are not capable of depicting these phenomena. To our knowledge, there has been no attempt to develop a coherent macroeconomic framework which incorporates the relations between the financial sector and the real economy so that it is able to explain financial cycles endogenously, and is at the same time calibrated to empirical data and fit to provide economic policy advice. There exist empirically calibrated or estimated models to depict boom-bust cycles in the DSGE modelling literature, but they face constraints in explaining these cycles endogenously, see Section 2 below. Empirically well-founded models that are comparable to the approach we conceptualize here such as Papadimitriou et al. (2013), Kinsella and Tiou-Tagba Aliti (2012) or Barwell and Burrows (2011), while in principle able to depict balance sheet interactions and financial fragility endogenously, do not focus on cycles similarly to the model proposed here.

We aim to bridge this gap. The primary objective of our research is to build a macroeconomic model that is capable of analysing recent economic developments and calibrate it to econonomic data for the Eurozone. Especially, we incorporate the endogenous build-up of credit-fuelled asset price bubbles and their effect on the real economy. These credit-fuelled asset price bubbles, which we henceforth define as 'Kindleberger cycles', arise endogenously in the model, primarily due to speculative lending, asset price inflation, pro-cyclical leverage effects and expectations of capital gains. They are at the core of our model mechanics.

Our modelling concept is based on a stock-flow consistent (SFC) framework (Godley and Lavoie, 2007). The specific properties of this approach enable us to coherently incorporate the institutional structure of a complex modern financial sector and the corresponding potential financial instability (Kinsella, 2011; Bezemer, 2010). It allows to explain the build-up of asset price bubbles and to evaluate macro-prudential regulation with respect to their effects on economic growth and the business cycle. Specifically, we include institutional details by explicitly accounting for the balance sheet composition of aggregated macroeconomic agents. These agents are firms, households, banks, the shadow banking sector, the government, and a central bank. The mechanism of the endogenous emergence of Kindleberger cycles features centrally in our model as follows: Banks endogenously create credit, which is used by other agents for investment, consumption, or speculative asset purchases. In the latter case, these funds may result in a rise in asset prices, which gives rise to capital gains and increases the net worth of all agents holding these assets. This in turn enables these agents to extend their liabilities by issuing securities (bonds or equity) or by a take up of new loans, a phenomenon which is known as a pro-cyclical leverage effect (Adrian and Shin, 2010). Banks securitise part of the loans on their balance sheets, inducing more financial assets to be created via the shadow banking system. Furthermore, securitisation reduces the balance sheet size of traditional banks and thus also their leverage, as well as their (direct) exposure to default risk. As a consequence, banks can provide new loans, fuelling the asset price bubble further if part of the loans is used for financial investment. This is likely due to the expectations of capital gains agents in the model have formed after the initial rises in asset prices. When demand for financial assets decreases, asset prices fall, and the balance sheets of agents holding these assets will experience a loss in net worth. Since the financial constraints of all agents are included in the model in a consistent way, this allows us to depict the impact of a burst of an asset-price bubble on overall economic dynamics.

We link these mechanisms to real economic activity via the investment decisions of firms. Firms may undertake investment in real capital or financial assets, depending among other factors on the expected return as in Caverzasi and Godin (2015). The price of real capital corresponds to a market value that is determined by supply-demand interaction (scarcity), e.g. on the housing market, and/or on the expected future returns (investment). Besides being determined by expected returns, the price of a financial asset, even if constitutes a claim on real capital or any form of collateral, additionally depends on the liquidity and solvency of a counterparty. Therefore, while financial assets may rise in value if expectations of capital gains are high, their price may fall abruptly in case liquidity is tight in the economic system or solvency of a counterparty is in question in an event of crisis. This will also influence the price of real capital once a crisis manifests, but the price swings of financial assets destabilise the economic system and govern its boom-bust dynamics. It is this qualitative difference in price dynamics between financial assets and real capital which is a major focus of our modelling project.

Thus we are able to capture the long-term effects of a growing financial sector on economic growth and financial fragility, distinguishing between growth of the real sector and growth in financial markets. The details of the balance sheets and the relations between the economic sectors are summarised in Section 3.

After calibrating model dynamics to the economic development of the past in a stylized way for this more conceptual paper, we will use it to conduct policy simuations to explore the properties of the model. A special focus will be put on the interaction between policy measures and possible unintentional effects, analysing positive synergies and reinforcement as opposed to joint detrimental effects. Thereby we explicitly address the boundary problem in financial regulation (Goodhart, 2008) by including the complexity of the financial sector in institutional detail. In this context, the boundary problem relates to the often-observed tendency that regulating only part of the financial sector shifts procyclical provision of credit to the still unregulated part of financial markets. Specifically, we can consider potential shifts of credit expansion from the traditional banking sector, which is increasingly subject to macro-prudential regulation, to the less regulated shadow banking sector within our evaluation of policy measures.

2 Literature Overview: Macroeconomic Modelling of Financial Markets and Macro-prudential Regulation

Financial booms and crises are among the most distinct features of the capitalist economy and their frequent historic recurrence is well documented, see Kindleberger and Aliber (2005). The build-up of booms usually contains irrational elements and biased expectations of future profits or price increases, and is thus hard to explain from an analytical perspective. Triggers for sudden financial collapse vary according to the unique coincidences and peculiarities of historic occasions. There are, however, common elements to all financial crisis that can and should be subjected to analytical treatment of suitable economic theory, not at least due to their current relevance in empirics and economic practice.

Keynes (1936) and Minsky (1986, 1982) argue that crises are mainly rooted in extended euphoria on financial markets, financial innovation, and an increasing leverage of financial and non-financial firms. Kindleberger and Aliber (2005) point out the importance of the creation of non-bank credit used for financial investment and speculation.[1] Furthermore, Werner (2012) distinguishes productive credit, which is used for real investment and leads

[1] It is the importance of the creation of non-bank credit, today especially within the shadow banking system, which we want to stress by naming the financial cycles central to our model design 'Kindleberger cycles'.

to GDP growth, and unproductive or speculative credit, which can lead to asset price bubbles. Jorda et al. (2015, 2013) point to the severe and long-term economic impacts of such credit-fuelled asset price bubbles. Likewise, Borio (2014) argues extensively for the presence of boom-bust cycles emanating from financial markets, and proposes that such cycles should explicitly be considered in macroeconomic modelling efforts. Despite the fact of the ample empirical evidence for financial cycles in past and present, explanations for their occurence were scarce in the macroeconomic modelling literature before the economic crisis in 2008/09 and most models are still not up to this task, see e.g. Borio (2014) and Bezemer (2011b).

The changing institutional structure of the financial sector is one of the strongest reasons for the occurence of financial cycles. Growing complexity and fragility of the financial system are both part of longer-term systemic and institutional developments of modern capitalism that have been labeled "financialisation". The most-often cited definition by Epstein (2005) broadly associates financialisation with the "increasing role of financial motives, financial markets, financial actors and financial institutions in the operation of the domestic and international economies." This definition encompasses various phenomena such as increasing shareholder value orientation of non-financial businesses, the increasing importance of institutional investors on financial markets, financial innovation processes and financial deregulation, the rise of the originate-and-distribute model of banking, as well as high and rising incomes in the financial sector, see Onaran et al. (2011) and the sources cited therein. A comprehensive analysis of the phenomen of financialisation can be found in Eatwell and Taylor (2001). Other contributions include Binswanger (2000), Skott and Ryoo (2008), and Krippner (2005), who focuses on the US economy, as well as Stockhammer (2008), who investigates the European case.

In this regard, one possible channel how an overly sized financial sector reduces real economic growth is that increasing returns on financial markets may induce economic actors, especially non-financial firms, to invest in financial assets rather than real capital. Thus, as is argued by Stockhammer (2004) and Orhangazi (2008), demand in the real economy is reduced by financial investment, which in turn reduces real economic growth unless the effect is over-compensated via another economic channel. A comparable distinction between productive and unproductive use of credit can be found in Werner (1997), Werner (2012).

Recent empirical evidence points to the fact that credit-fueled asset price bubbles produce an entirely different crisis phenomenon than bubbles due to "irrational exuberance"[2], Jorda et al. (2015, 2013). The former type of credit-driven bubbles (Kindleberger cycles) causes deeper and longer recessions. This empirical evidence based on long-run historical data for several countries critically supports the relevance of the central mechanism within our model design.

In case a credit-fuelled asset price bubble develops, pro-cyclical leverage effects will exacerbate the situation. Rising value of assets on financial intermediaries' balance sheet will improve their net worth, which is the residual on the liability side of their balance

[2] I.e. wrong and implausibly euphoric expectations of agents on financial markets.

sheet, and thus lower their leverage, see Adrian and Shin (2010). This balance sheet effect will induce financial institutions to further extend credit potentially leading to a continued bidding up of asset prices. Once one of these credit-driven bubbles bursts, it will most likely lead into a balance sheet recession (Koo, 2003), where various economic agents, possibly households, firms, banks, the financial sector, the government and/or the foreign sector try to reduce their liabilities to improve their leverage. This has severe medium to long-term contractive effects on the economy as effective demand decreases, especially if all or many of the agents above try to deleverage at the same time.

Macro-prudential regulation is seen as essential for a financial system that healthily contributes to equitable and strong growth, as is argued by the OECD in Cournède et al. (2015). Along with implementing sufficient capital buffers and restructuring of the financial sector, such regulation would prevent the build-up of credit-fueled asset price bubbles. However, any attempt for macro-prudential policy making by regulating a part, such as the traditional banking system, of a complex financial system is likely run into the boundary problem (Goodhart, 2008; Schoenmaker and Wierts, 2015). Extended credit creation will shift to a still unregulated part of the banking sector such as the shadow banking system. As leverage will follow asset price movements pro-cyclically due to balance sheet effects, any asset price changes are likely to be exacerbated within the financial sector without regulation of the system as a whole, see Schoenmaker and Wierts (2015).

Even though the topic of financial cycles has been picked up in macroeconomic model building, particularly since the recent financial and economic crisis, most models fail to account comprehensively for the complexity and the changing nature of the financial system. Especially attempts to include a systematic explanation and simulation of interaction between the financial and the real economy into a macroeconomic framework are limited, see e.g. Borio (2014) or Bezemer (2011b, 2012).

A certain strand of the dynamic macroeconomic modelling literature has been increasingly concerned with implementing financial markets and their interaction with the real economy in a real business cycle model. Examples are Brunnermaier and Sannikov (2014), Christiano and Ikeda (2013), Kyotaki and Moore (2012), or Gertler and Karadi (2011), among many others. Bauducco et al. (2014) and Christiano et al. (2010) provide recent overviews. The modelling strategy mostly involves including financial frictions in macroeconomic equilibrium models following the New Keynesian Dynamic Stochastic General Equilibrium (DSGE) paradigm, see Borio (2014) and **?**. By this approach, nominal rigidities augment real business cycle fluctuations that are very often based on exogenous productivity shocks and amplify these business cycles or impediate the return of the model to an equilibrium growth path.

While this approach is well established , it fails to grasp the endogenous features of Kindleberger cycles in several ways. Firstly, credit-fuelled financial cycles are rooted in an expansion of the money supply by the issuance of new debt. In the overwhelming majority of DSGE models, money is treated as a veil. Exceptions are nominal frictions, mostly in price formation or provision of lending, in New Keynesian DSGE models. Any such lending mechanism, however, works entirely by the loanable funds theory, and does not consider banks creating money along with debt[3] - a fact that has become consensus in monetary economics literature or in publications by central banks, often under the label 'endogenous money'.[4] Secondly, the DSGE approach makes the assumption that the model always returns to an equilibrium growth path (steady-state) automatically, unless it is disturbed to do so by exogenous shocks, various frictions or nominal rigidities. Hence DSGE models cannot adequately account for inherently evolving economic dynamics, which is necessary in order to depict endogenous build-ups of bubbles and crashes. Thirdly, this approach also fails to depict the true endogenous interaction between financial markets and the real sector, specifically balance-sheet effects and positive feed-back effects between growth and asset price inflation, see Bezemer (2012, 2011a).

Due to these three reasons, the endogenous rise of credit-fuelled bubbles (Kindleberger cycles) and their potential detrimental effects on the real economy cannot be treated comprehensively in this class of models.

In another recent strand of the literature, numerous endeavours have been made to incorporate problems relating to financialisation building on the stock-flow-consistent macroeconomic originally developed by Backus et al. (1980), Tobin (1969), Tobin (1982), and Godley and Lavoie (2007). These models, based on the SFC paradigm, avoid much of the theoretical challenges the DSGE approach faces when analytically describing financial cycles as argued above. Examples of such models include (albeit not exhaustively) Van Treek (2009), Lavoie (2008), Dos Santos and Macedo e Silva (2009), Le Heron and Mouakil (2008), Le Heron (2011), Skott and Ryoo (2008), Reyes and Mazier (2014), Nikolaidi (2014), Caverzasi and Godin (2015), Bhaduri et al. (2015), Khalil and Kinsella (2015).

These models are mainly theoretical, and are not estimated to actual economies or aim to provide policy options. Financial cycles are generally not considered or focused on, rather the costs of different manifestations and phenomena of financialisation in the long run. The distinction between productive and unproductive credit is usually not made explictly or not related to boom-bust cycles. Furthermore, macro-prudential regulation, government intervention or central bank policy are not accounted for in most of the cases. None of these contributions depicts a complex financial sector including a shadow banking sector in interaction with real economic growth in order to endogenously model Kindleberger cycles as put forth in this proposal.

Another number of model focuses on financial cycles and/or financial instability. However, these are much smaller models, often in continuous time and based on few differential equations that can be solved analytically. Examples include Bezemer (2012), Bhaduri

[3] The only exceptions of an explicit considereation this fact ('endogenous money') in DSGE models known to the authors are Jakab and Kumhof (2014) and Benes and Kumhof (2012).

[4] The theory of endogenous money has been established for a long time in several strands of economic literature. See among many others McLeay et al. (2014), Keister and McAndrews (2009), Berry et al. (2007), Nichols and Gonczy (1992), Bundesbank (2012), Godley and Lavoie (2007), Moore (1988), Minsky (1982, 1986), Keen (1995), and Schumpeter (1911) for a by far non-exhaustive or representative list.

(2011), Keen (1995, 2013), Peetz and Genreith (2011) or Passarella (2012), among others.

While these show the underlying mechanisms of financial instability, as well as financial and debt crises, they mostly abstract from certain features of the economy such as real capital vs. financial capital, a complex financial sector including institutional detail, a government sector, a central bank, the distribution of wealth and income, or the like, that complete the picture of an economic system.

The number of what Caverzasi and Godin (2014) define as "fully empirical" SFC models that would be similar in spirit to the model proposed in this application is very limited. According to their definition of fully empirical SFC models, not only are the model parameters estimated from empirical data, they are also used to predict variations of endogenous model variables in a scenario analysis. Caverzasi and Godin (2014) name two groups that work with this kind of fully empirical SFC models: one set of authors at the Levy institute, who constructed fully empirical models for the U.S. (Papadimitriou et al., 2011) and Greek economies (Papadimitriou et al., 2013). The other goup can be found at the University of Limerick, see Kinsella and Tiou-Tagba Aliti (2012), where an empirical model of the Irish economy is still work in progress. A further model for the UK economy was devised by Barwell and Burrows (2011). However, none of these models features endogenous financial cycles or a complex financial market comparable to our modelling concept.

A macroeconomic model that allows for a true dynamic beyond assumptions of the economy endogenously and automatically returning to a steady state or an equilibrium growth path can be capable of depicting financial cycles endogenously with a perspective on policy analysis. Moreover, the assumption of endogenous money, i.e. the creation of money by banks through the provision of credit, which is incorporated in SFC models, is a crucial starting point to understand why asset prices form and how they evolve due to the increased provision of credit. The boundary problem and the complexity of the financial system can be considered by differentiating between a capital market based financial system, including an explicit depiction of the 'Shadow banking sector', besides a 'traditional' commercial banking sector.

In difference to the models above, we intend to incorporate dynamic economic developments comprehensively: Instead of determining the path that the model will take a priori, we analyze developments in the data, and construct the model equations according to these developments. We then estimate all parameter values, so that the evolution of the model variables fits actually observed dynamics in the recent past. Forecasting these parameter values allows us to get the resulting dynamic as a solution of the model. Using this dynamic approach, business cycles emanating from the change in the structure of the financial sector will be a truly endogenous feature of our model. Therefore, our model as set out further in Section 3 would both extend the literature in this field and provide a valuable tool for policy advice.

Taking on a policy dimension and following the challenges to economic theory by bridging a gap in the literature, our research has the following main objectives:

3 The Model

3.1 Theory

Our model is based on the stock-flow consistent (SFC) approach, which goes back to Backus et al. (1980), Tobin (1969), and has recently seen a revival in the literature through the seminal work of Godley and Lavoie (2007).[5] The main feature of SFC models is that they account for flows and stocks within and between various sectors of the economy, in a way that there are no 'black holes'. Flows denote transactions (e.g. public spending, or the amount that the household invests in different financial assets) while stocks denote sizes of asset positions on the active and passive sides of an agents' balance sheets (e.g. government debt, or the size of positions of different financial assets held by the household sector). In a stock flow consistent model each flow comes from one sector and goes to another. The corresponding stocks are reduced, respectively increased, by the size of the flow. Just as flows lead to a change in stocks (e.g. net worth), stocks can have an influence on flows (e.g. net worth is a determinant of consumption).

Because of the ability to explicitly depict money and other asset classes, the SFC literature has faced some revival since the 2008/09 financial crises. As reported in Section 2, various aspects of financialisation have been included in SFC models. More recently, some papers have started to incorporate a shadow banking sector and securitisation in an SFC framework. Examples include Bhaduri et al. (2015) and Nikolaidi (2014). We build on this literature but extend the models both theoretically and empirically.

Technically, any SFC model is formulated as a dynamical system of difference equations. The behavior of such a system depends on the functional relations between the variables (i.e. the model equations), the parameter values, and the initial conditions. A model can either be unstable with the value of the variables in time going to infinity (diverging behavior), or converge to a stationary point or a limit cycle (converging behaviour). In this context, an balanced growth path corresponds to divergent behavior, where all variables diverge at the same growth rate.

Most models depicting theoretical phenomena are calibrated to a stationary state, which is used as a basis for policy experiments or the analysis of shocks. There exist also empirical models, which are calibrated to past data, see e.g. Kinsella and Tiou-Tagba Aliti (2012), that discuss several techniques. In a similar style, we do not restrict the model to a predefined dynamic, but obtain an endogenous dynamic as determined by the model equations and by the calibration of parameters. This calibration procedure ensures that model variables will fit the development of observed data from the recent past.

3.2 Modelling Financialisation and Kindleberger Cycles

This section describes how the phenomena of financialisation and financial cycles, as discussed in sections 1 and 2, are depicted in the model. Specifically, we describe how

[5] See Caverzasi and Godin (2014) for a recent overview of the SFC literature.

we model the above defined Kindleberger cycle. We use different mechanisms leading to the build-up of a credit-fuelled asset price bubble in the model, and also different trigger events, leading to the burst of such a bubble.

Firstly, the definition of a financial bubble in this framework will be as follows: 1. the expectations of price increases are lower than the actual price developments for all agents in the economy, 2. returns on financial assets averaged over all asset classes are higher than returns to real capital. This definition captures the common perception of bubbles as large and sustained mispricings of assets, cf. (Brunnermaier and Oehmke, 2013, p. 12), and incorporates the unsustainable nature of a bubble in our model due to financial returns overtaking real returns in a bubbly economic environment.

As is consensual for financial markets, if nominal demand for financial assets is higher than the nominal supply of financial assets, the price will rise, thus equilibrating the asset market. Hence, in order to depict a Kindleberger-type asset price bubble in our formal model, we introduce a mechanism that consists of two parts. In a first step, we stimulate a rise in demand for a certain asset class exogenously. The cause for this is mainly due to the deregulation of financial markets, depicted in the rise of the OFI sector. Trigger events can be changes in portfolio preferences, or a specific set of initial conditions or dynamics at a certain time period, see below. Secondly, the mechanism must make sure that this rise in demand triggers an endogenously accelerating positive feedback loop between two or more agents in the model, relating credit creation to financial investment. Once triggered, this loop keeps pushing the demand for, and hence the price of the asset endogenously, thus forming a bubble.

We distinguish between three main channels of credit creation in our model, the features of which as regarding the amplitude and duration of the corresponding credit-fuelled asset price bubbles and the detrimental effects of the potential burst will be explored:

1. Credit creation within financial system:
    - Creation of "OFI (other financial institutions) shares", i.e. shares of various funds (money market mutual funds, investment funds, other financial intermediaries, etc.), the proceeds of which are used to purchase other financial assets such as stocks, bonds, etc.
    - (Repo) loans: commercial banking sector to OFIs; e.g. securitised loans as collateral
2. Increased provision of loans by commercial banking sector to HHs and NFCs (improved leverage; financial risk-taking in boom economy)

The concrete manifestation of the initial (exogenous) trigger can take various forms at different times. Currently, we consider four specific types:

1. More credit for speculative reasons.
Here we consider an increase in the credit supply, by banks and the OFI sector, that is channeled into investment in financial assets and tends to inflate asset prices.

2. Decreasing returns in real economy.
If returns to financial investment become more profitable relative to real investment, firms are induced to shift to financial rather than real investment according to their portfolio choice. Caverzasi and Godin (2015) provide such a mechanism in an SFC model.

3. A rise in profits relative to wages.
An increasing gap in income and wealth between the worker and the rentier household further increases financial fragility. This is due, on the one hand, to increased borrowing by the low-income and low-wealth worker household, see Stockhammer (2015), or Kumhof et al. (2015). Another reason is the rentier's portfolio choice; if relatively more funds are going to the rentier than to the worker, then there is also proportionally more financial investment than consumption.

4. A preference shift of households.
An increasing propensity of the rentier household to invest in OFI shares will increase demand for these assets and hence tend to inflate asset prices.

The way we model the endogenous feedback loops leading to the build-up of the bubble is as follows. In each of the above trigger cases, there is a rise in nominal demand for financial assets. As mentioned above, if there is more money available for demanding financial assets than the nominal value of financial assets, prices rise. Increasing asset prices then induce **pro-cyclical leverage effects**, Adrian and Shin (2010). As the value of financial assets held by firms and households rise, also their net welath rises. Through these capital gains, firm and household leverage decreases, and they can take up more new loans. Since also banks hold some of these assets, their net worth rises, improving their leverage ratio, allowing also the issuance of more credit. For banks, however, there is an additional effect; securitising loans from firms and households, and selling these to the OFI sector, improves their leverage even more.

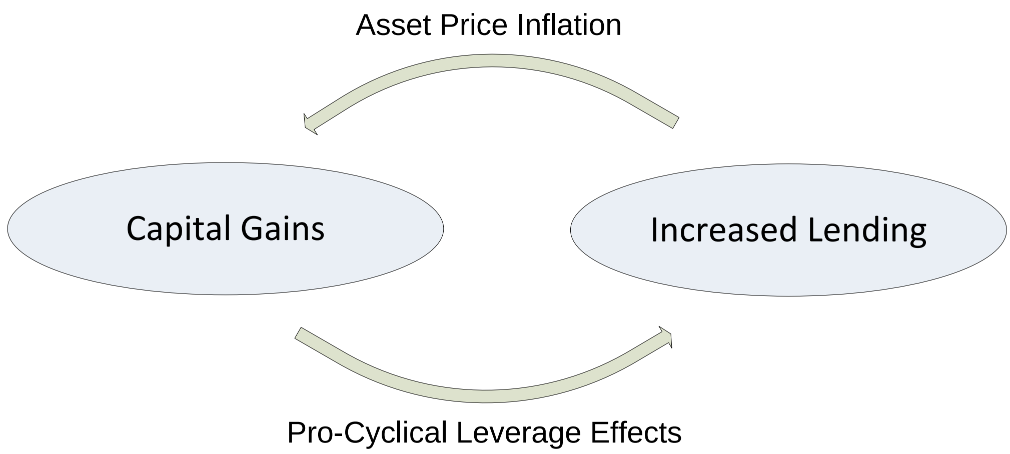
These additional lending possibilities can be drawn upon by firms and households, who use the new funds for real investment (housing and capital stock). The housing market plays a special role. Firstly, increased mortgage lending further fuels the credit cycle by providing more collateral for loans and securitisation. Secondly, increased lending or rising profits generally imply not only a rise in prices of financial assets, but also a rise in demand and hence prices for housing. This price rise might even be steeper, since the stock is quasi limited. Also here capital gains imply a pro-cyclical leverage effect, and may start a lending fuelled boom. Nikolaidi (2014) provide a similar mechanism in an SFC model.

While conventional bank credit may be used mainly for real investment, in their portfolio choice households and firms shift to financial assets due to higher returns of OFI shares compared to more traditional forms of saving (deposits). Hence the main feature of increased bank lending is that, thinking in aggregate terms, the newly created credit is channelled back into the financial sector to a high degree.

The **shadow banking** sector plays a very complex and probably the most important role in our framework. OFIs issue shares (near-monies), which are bought by households, firms and banks as assets in return for cash/deposits. Issuing shares, this sector expands the supply of non-bank credit. Regulation in respect to the leverage ratio (outstanding shares to net worth) is much less stringent for OFIs than for the banking sector. In search for a high yield, OFIs use the revenues from their share sales to purchase equity, bonds and securities, thus also indirectly raising demand for financial assets. Rising demand for financial assets again raises prices, yielding capital gains and improved leverage.

As this process iterates, the dynamic also reinforces all of the initial trigger situations. Such a boom is actually characterised by (1) increased lending for speculative reasons, (2) increasing returns on financial investment (and decreasing real returns), (3) a worsening of the functional income and wealth distributions, due to capital gains, and (4), a preference shift towards financial investment due to further expected capital gains.

Figure 1: Central Model Mechanism: Dynamics of a Kindleberger Cycle



While the build-up of a Kindleberger-type asset price bubble is quite similar in each case, the initial triggers of the mechanism, as described above, vary according to historical circumstances. The same is true for the timing of and the reason for the burst of such a bubble.

In a historical perspective, the importance of bank credit (used for real investment) is typically diminishing during the course of a long swing of a financial cycle, while the importance of non-bank credit (the issuance of OFI shares that fuel demand for financial assets) is increasing. Once it exceeds a certain size, the OFI sector is left with a severe liquidity problem. On its balance sheet short term liabilites, the OFI shares that can be claimed any time, are opposed by long term assets, such as bonds, equity, and securities. A run on these near-monies (OFI shares) is the classic trigger for the burst of an asset price bubble, see Pozsar et al. (2013).

Another crucial matter arises from securitisation. We model securitisation techniques similar in spirit to Bhaduri et al. (2015) and Nikolaidi (2014). As OFIs buy securities from banks, they take risk off the balance sheets of banks, who improve leverage ratios. The risk however accumulates at the OFIs banlance sheets, though in the somewhat hidden form of securities. This creates another possibly severe instability emanating from the unregulated OFI sector. As loans may default, OFIs face the risk of a devaluation of its assets, and may not be able to pay all their depositors, a situation that would again lead to a run on OFI shares.

It will be crucial to specify at what point and due to what reason the asset price bubble breaks and potentially leads to a crisis. This will be determined by a mechanism in the model, depending on certain endogenous indicators, e.g. the debt-to-GDP ratio, see also Godley and Lavoie (2007) for similar mechanisms in SFC models. Certain parameters in behavioural functions will be made endogenous in the sense that they are first kept constant, and then change their values continuously, if a certain ratio rises above or below a certain threshold. This represents a prudential behavioural reaction of the agent, induced by some looming constraint that the agent might face, e.g. a budget constraint.

Specifically, households may reduce demand for new consumption loans in the case when the debt-to-wage ratio has risen above a certain threshold. This could reduce consumption, and multiply into reduced real output growth. Demand for government bonds might go down in the case that the public debt-to-GDP ratio exceeds some limit. A high level of the price-earnings ratios on firm equity may induce households, banks and OFIs to disinvest in firm equity. Households may also reduce demand for OFI shares in several cases. For example, this could happen if the OFI sector's debt-to-equity ratio becomes too large, if the amount of reliable collateral in the economy seems too low, or if the share of risky assets in the household's balance sheet may be too high. Following Vague (2014), another possible "debt algorithm" would be a crisis once 1. growth of the private-debt-to-GDP ratio of more than 18 % within the last 5 years 2. a private-debt-to-GDP ratio of more than 150 % is reached in level. All these incidences would lead to a reduced demand for certain asset types, setting a negative impulse to the corresponding price.

These trigger points (the ceilings for the various ratios) are set exogenously, while they are invoked by the endogenous model dynamics. The way the model reacts to these events, once triggered, depends on the specification of the model equations, but is truly endogenous. Typically, in a downward movement of asset prices, net worths of agents will shrink due to negative capital gains. Thus it is quite probable in such a case, that behavioural reactions of many other agents will be triggered soon after, leading into a downward spiral. In this way we can depict the burst of an asset price bubble, and its overall economic effects.

3.3 Notation

In the following, all endogenous variables that depict levels of variables (actual financial stocks and flows) are denoted by uppercase latin letters (e.g. L). Growth, interest and return rates as relative differences to previous levels are declared using lowercase latin letters (e.g. g, r, i). All parameters are indicated by lowercase greek letters (e.g. λ). All endogenous price variables are denoted by a latin lowercase p. Upper case latin subscripts refer to asset classes (e.g. p_B). Lower case latin subscripts declare an agent that holds an asset/liability or receives/pays a financial flow (e.g. F_b, B_h). The absence of an agent-related subscript denotes total supply/demand of an asset (e.g. D). Lower case superscripts s and d denote supply and demand for an asset/liability (demand before knowing the realized value), respectively (e.g. E^s, O_h^d). A case of no superscript for an endogenous variable indicates realized demand or supply. A lowercase superscript e denotes an expected value for a variable (e.g. r_K^e, A_b^e), a lowercase superscript t indicates a target variable (e.g. A_f^t). Upper case latin superscripts D and U indicate either whether a financial flow is distributed to other agents or retained ("undistributed") by an agent (e.g. F^D, FO^U). Uppercase superscripts QE indicate variables that are set exogenously by the central bank in line with their quantitative easing program (e.g. R^{QE}). Time indices are generally abstracted from for reasons of simplicity. Rather, we assume all stocks and flows to be denoted for the current period t, unless a subscript -1 denotes a stock or flow relation to the previous period $t-1$ (e.g. $D_{h,-1}$).

3.4 Balance Sheets

We start out from a set of aggregated financial balance sheets for the following macroeconomic sectors: Households (h), the government (g), firms (f), commercial banks (b), a central bank (cb), and shadow banks (ofi, Other Financial Institutions). All sectors hold different types of assets and liabilities: As financial assets we consider deposits (D), loans (L), firm equity (E), government bonds (B), securities (SEC), OFI shares (OFIs), and central bank reserves (R) as well as advances (A) in the model. Since in a modern economy any financial asset is created together with a financial liability, each financial asset of a sector (the holder/creditor) is a financial liability for another sector (the issuer/debtor). There are two non-financial (real) assets in the model, which have no liability counterpart, physical capital K (held by firms), and houses H (real estate, held by households). The difference between the assets and liabilities of a sector is its net worth V (see figure 2 below for the complete balance sheets, table 1 below for the balance sheet matrix and table 2 for the transaction flow matrix).

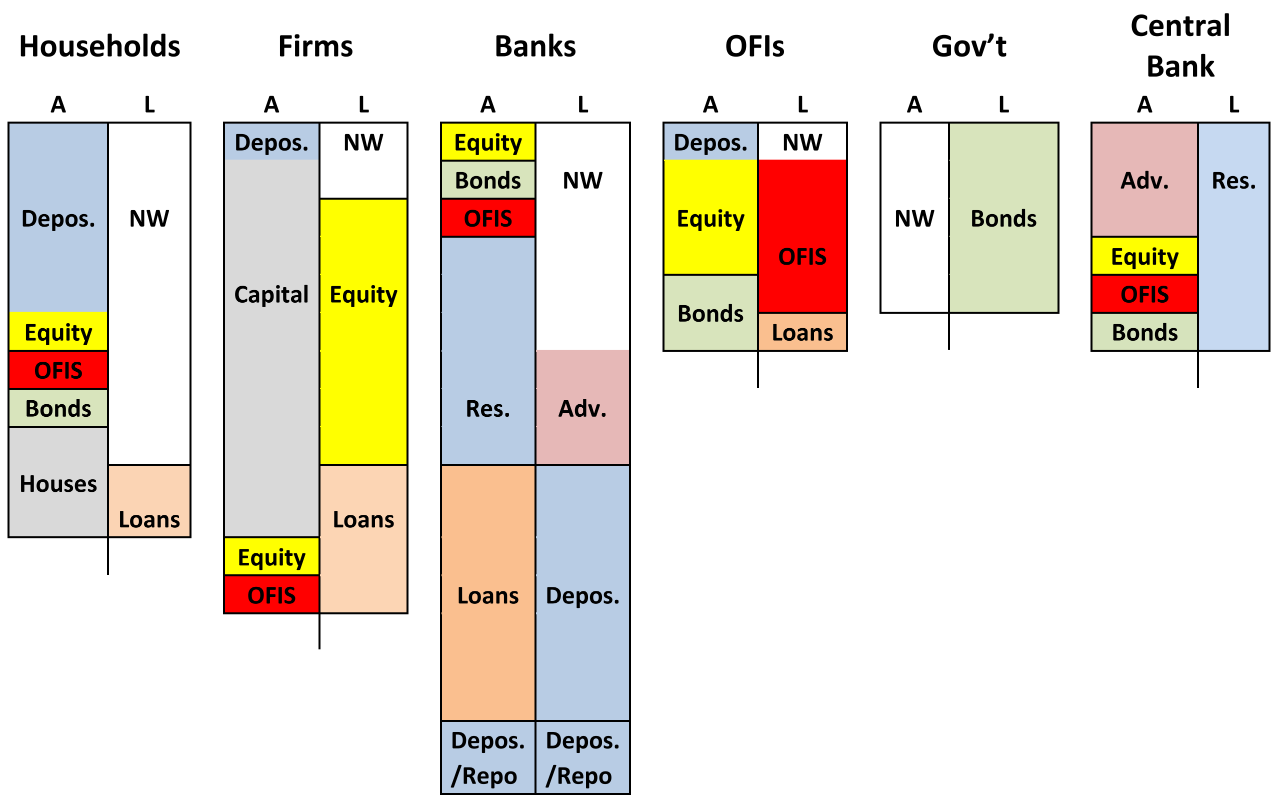


Figure 2: *Balance sheets of all asset holding agents of the economy.*
OFIS: other financial institutions' shares
Scales are not representative for Eurozone

3.5 Matrices

Table 1: Balance Sheet Matrix (BSM)

Assets \ Sectors	**Households**	**Firms**	**Banks**	**OFIs**	**Gov**	**CB**	Σ
Deposits	$+D_h$	$+D_f$	-D	$+D_o$			0
Equities	$+p_e.E_h$	$-E^s + p_e.E_f$	$+p_e.E_b$	$+p_e.E_o$		$+p_e.E_{cb}$	$\sum_t CG_E$
Bonds	$+p_b.B_h$		$+p_b.B_b$	$+p_b.B_o$	$-B$	$+p_b.B_{cb}$	$\sum_t CG_B$
Houses	$+p_h.H$						$+p_h.H$
OFI Shares	$+p_O.O_h$	$+p_O.O_f$	$+p_O.O_b$	$-O$		$+p_O.O_{cb}$	$\sum_t CG_O$
Loans	$-L_h$	$-L_f$	+L	$-L_o$			0
Real K		+K					K
Reserves			+R			-R	
CB Advances			-A			+A	
Net Worth	V_h	V_f	V_b	V_o	V_{gov}	V_{cb}	V

Table 2: Transaction Flow Matrix (TFM)

	HH	**Firms current**	**Firms capital**	**Banks**	**OFIs**	**GOV**	**CB**	$\sum$
Real Side								
Consumption	-C	+C						0
Wages	+ W	$-W$						0
Taxes	$-T$					+T		0
Investment		$+I$	$-I$					0
Govt, Spending		$+G$				-G		0
Financial Side								
Deposit Interest	$+i_D D_{h,-1}$	$+i_D D_{f,-1}$		$-i_D D_{-1}$	$+i_D D_{o,-1}$			0
Interest on Bonds	$+i_B B_{h,-1}$			$+i_B B_{b,-1}$	$+i_B B_{o,-1}$	$-i_B B_{-1}$	$+i_B B_{cb,-1}$	0
Interest on Loans	$-i_L L_{h,-1}$	$-i_L L_{f,-1}$		$+i_L L_{-1}$	$-i_L L_{o,-1}$			0
Interest on OFI shares	$+i_O\ O_{h,-1}$	$+i_O\ O_{f,-1}$		$+i_O\ O_{b,-1}$	$-i_O\ O_{-1}$		$+i_O\ O_{cb,-1}$	0
Dividends	$+F_h$	$-F^D$	$+F_f$	$+F_b$	$+F_o$		$+\ F_{cb}$	0
Retained Earnings		$-F^U$	$+F^U$					0
Bank profits	$+FB^D$			$-FB^D$				
CB profits						$+\Pi_{cb}$	$-\Pi_{cb}$	
Total saving	SAV_h	0	SAV_f	SAV_b	SAV_o	SAV_{gov}	SAV_{cb}	0
Changes in Stocks (Uses and Sources of funds)								
Deposits	$-\Delta D_h$		$-\Delta D_f$	$+\Delta D$	$-\Delta D_o$			0
Firm Equities	$-p_E\Delta E_h$		$-p_E\Delta E_f$ $+\Delta E^s$	$-p_E\Delta E_b$	$-p_E\Delta E_o$			0
Bonds	$-p_B\Delta B_h$			$-p_B\Delta B_b$	$-p_B\Delta B_o$	$+p_B\Delta B$	$-p_B\Delta B_{cb}$	0
OFI shares	$-p_O\Delta O_h$		$-p_O\Delta O_f$	$-p_O\Delta O_b$	$+p_O\Delta O$		$-p_O\Delta O_{cb}$	0
Loans	$+\Delta L_h$		$+\Delta L_f$	$-\Delta L$	$+\Delta L_o$			0
Real Capital			$-\Delta K$					$-\Delta K$
Advances				$+\Delta A$			$-\Delta A$	0
Reserves				$-\Delta R$			$+\Delta R$	0
Revaluation Gains/Losses								
Firm Equities	$+\Delta p_E E_{h,-1}$		$+\Delta p_E E_{f,-1}$	$+\Delta p_E E_{b,-1}$	$+\Delta p_E E_{o,-1}$			CG_E
Bonds	$+\Delta p_B B_{h,-1}$			$+\Delta p_B B_{b,-1}$	$+\Delta p_B B_{o,-1}$		$+\Delta p_B B_{cb-1}$	CG_B
OFI shares	$+\Delta p_O O_{h,-1}$		$+\Delta p_O O_{f-1}$	$+\Delta p_O O_{b,-1}$			$+\Delta p_O O_{cb,-1}$	CG_O
Houses	$+\Delta p_h$ $H(const)$							Δp_h $H(const)$
Δ Net Worth	ΔV_h	0	ΔV_f	ΔV_b	ΔV_o	ΔV_{gov}	ΔV_{cb}	

3.6 Behavioural Equations

3.6.1 Expectations

We assume expectations to be adaptive, see Godley and Lavoie (2007), and to be formed as in Caverzasi and Godin (2015) for any variable X in the model unless specified differently. They are given by a weighted average of past observations $\overline{X}$ (possibly of the last four to five observations), and include an adaption mechanism. This adaptation mechanism takes into account the development of a variable from the last period as regarding the expectation gap, i.e. the gap between the expected value X^e_{-1} and the realised value X_{-1} within the last period, subject to an adjustment parameter ζ:

$$X^e = \overline{X} + \zeta(X^e_{-1} - X_{-1}) \tag{1}$$

3.6.2 Returns

Returns to the respective assets are composed of interest flows (bonds, OFI shares), dividends (equities) or profits plus capital gains for the respective asset class. We follow Caverzasi and Godin (2015) in discounting the capital gains by a fixed factor ψ, i.e. agents in the model are conservative in their estimation of past and their expectation of future capital gains.

$$r_E = \frac{F^D + \psi CG_E}{p_{E,-1} \cdot E_{-1}} \tag{2}$$

$$r_B = \frac{i_B B + \psi CG_B}{p_{B,-1} \cdot B_{-1}} \tag{3}$$

$$r_O = \frac{i_O O + \psi CG_O}{p_{O,-1} \cdot O_{-1}} \tag{4}$$

$$r_H = \frac{\psi CG_H}{p_{H,-1} \cdot H_{-1}} \tag{5}$$

3.6.3 Households

Decisions: 1) cons/sav, 2) PC

disposable income:

$$YD = W - T + F_h + FB^D + i_D.D_{h,-1} + i_B.B_{h,-1} + i_O.O_{h,-1} - i_L.L_{h,-1} \tag{6}$$

$$\tag{7}$$

borrowing: Households take up all loans supplied by banks, i.e. we assume a supply constraint on household loans in line with the literature (Caverzasi and Godin, 2015).

$$\Delta L_h^d = \Delta L_h^s \quad (8)$$
$$L_h = L_{h,-1} + \Delta L_h^s \quad (9)$$

spending decision: [6]

$$C = \alpha_1.YD^e + \alpha_2.V_{h,-1} + [\alpha_3.\Delta L_h^e + \alpha_4.CG_h^e] \quad (10)$$
$$[D_h^d = (\lambda_h^{10} + \lambda_h^{11}.i_D - \lambda_h^{12}.r_E^e - \lambda_h^{13}.r_B^e - \lambda_h^{14}.r_O^e - \lambda_h^{15}.r_H^e).A_h^e] \quad \text{deposits are buffer stock}$$
$$E_h^d.p_E = (\lambda_h^{20} - \lambda_h^{21}.i_D + \lambda_h^{22}.r_E^e - \lambda_h^{23}.r_B^e - \lambda_h^{24}.r_O^e - \lambda_h^{25}.r_H^e).A_h^e \quad (11)$$
$$B_h^d.p_B = (\lambda_h^{30} - \lambda_h^{31}.i_D - \lambda_h^{32}.r_E^e + \lambda_h^{33}.r_B^e - \lambda_h^{34}.r_O^e - \lambda_h^{35}.r_H^e).A_h^e \quad (12)$$
$$O_h^d.p_O = (\lambda_h^{40} - \lambda_h^{41}.i_D - \lambda_h^{42}.r_E^e - \lambda_h^{43}.r_B^e + \lambda_h^{44}.r_O^e - \lambda_h^{45}.r_H^e).A_h^e \quad (13)$$
$$H^d.p_H = (\lambda_h^{50} - \lambda_h^{51}.i_D - \lambda_h^{52}.r_E^e - \lambda_h^{53}.r_B^e - \lambda_h^{54}.r_O^e + \lambda_h^{55}.r_H^e).A_h^e \quad (14)$$
$$A_h^e = A_{h,-1} + YD_h^e - C + \Delta L_h^e + CG_h^e \quad (15)$$
$$(16)$$

The stock of houses H is assumed to be fixed.[7] Deposits held by households (D_h) are assumed to be buffer stocks, i.e. the asset that adapts to account for expectations mistakes in households' portfolio choice.

Capital gains:

$$CG_{h,E} = \Delta p_e \cdot E_{h,-1}$$
$$CG_{h,b} = \Delta p_b \cdot B_{h,-1}$$
$$CG_{h,H} = \Delta p_H \cdot H_{-1}$$
$$CG_{h,O} = \Delta p_O \cdot O_{h,-1}$$
$$CG_h = CG_{h,E} + CG_{h,B} + CG_{h,H} + CG_{h,O} \quad (17)$$

balancing:

$$A_h = A_{h,-1} + YD_h - C + \Delta L_h + CG_h \quad (18)$$
$$D_h = A_h - E_h.p_E - B^d.p_B - O_h^d.p_O - H^d.p_H \quad (19)$$
$$V_h = A_h - L_h \quad (20)$$

[6] Besides the traditional Modigliani-Miller consumption function, we might include a term related to change in household debt $\alpha_3.\Delta L_h^e$, and/or one related to their expected capital gains $\alpha_4.CG_h^e$.
[7] Alternative: H could grow with the real rate of economic growth.

3.6.4 Firms

Decisions: 1) wages, 2) profits, 3) growth, 4) PC, 5) financing E vs. L

production, wages and profits:

$$Y = C + I + G \tag{21}$$
$$\Pi_f = Y - W + i.D_{f,-1} + i_O.O_{f,-1} - i_l.L_{f,-1} \tag{22}$$
$$W = Y.ws \tag{23}$$
$$F^U = \xi_f.\Pi_f \tag{24}$$
$$F^D = (1 - \xi_f).\Pi_f \tag{25}$$
$$F_a = F^D.\frac{E_a}{E^s} \quad \forall a \in \text{agents holding equity} \tag{26}$$

asset growth decision:

$$g_A^t = \gamma_1.[r_{f,TOT}^t - r_{f,TOT}^e] \tag{27}$$
$$I_A = A_{f,-1}.g_A^t + \delta_k.K_{-1} \tag{28}$$
$$A_f^t = A_{f,-1}.(1 + g_A^t) \tag{29}$$
$$r_{f,TOT} = \frac{F^U + F_f + i_O O_f + \psi CG_f}{A_{f,-1}} \tag{30}$$
$$r_{f,TOT}^t = \overline{r}_{TOT,-1} + \mu_f \tag{31}$$
$$\overline{r}_{TOT} = \frac{i_D D_{-1} + i_B B_{-1} + i_L L_{-1} + i_O O_{-1} + F^D + FB^D + \psi \sum_a CG_a}{\sum p_A A + L + D} \tag{32}$$
$$\text{for} \quad a = \{h, f, b, ofi, cb\}, \quad A = \{B, O, E, H\}$$
$$r_K = \qquad r_K = \frac{Y - W}{(Y - W)_{-1}} \tag{33}$$

where g_A^t is the total target asset growth rate for firms, $r_{f,TOT}^e$ are the expected returns to the total asset portfolio of firms, $r_{f,TOT}^t$ is the target total return rate of firms, and r_K is the return rate to real capita. The parameter ψ captures the extent to which capital gains are considered as part of the return rates to an asset. Additionally, $\overline{r}_{TOT}$ represents an average economy-wide return rate capturing both the total length of balance sheets and the returns earned to these balance sheets in the economy, and μ_f is a markup placed by firms on this economy-wide return rate to determine their target return rate (functional form yet to be determined, could be constant for first model version).

portfolio decision:

$$[D_f^d = (\lambda_f^{10} + \lambda_f^{11}.i_D - \lambda_f^{12}.r_E^e - \lambda_f^{13}.r_K^e - \lambda_f^{14}.r_O^e).A_f^t] \quad \text{deposits are buffer stock}$$

$$p_e.E_f^d = (\lambda_f^{20} - \lambda_f^{21}.i_D + \lambda_f^{22}.r_E^e - \lambda_f^{23}.r_K^e - \lambda_f^{24}.r_O^e).A_f^t \tag{34}$$

$$K^d = (\lambda_f^{30} - \lambda_f^{31}.i_D - \lambda_f^{32}.r_E^e + \lambda_f^{33}.r_K^e - \lambda_f^{34}.r_O^e).A_f^t \tag{35}$$

$$p_O.O_f^d = (\lambda_f^{40} - \lambda_f^{41}.i_D - \lambda_f^{42}.r_E^e - \lambda_f^{43}.r_K^e + \lambda_f^{44}.r_O^e).A_f^t \tag{36}$$

$$I = \Delta K + \delta_k.K_{-1}, \qquad (\Delta K = K^d - K_{-1}) \tag{37}$$

Again, firms' deposits (D_f) here are assumed to be the buffer stock.

financing decision:

$$E^s = \min\left[\frac{\chi_f(I_A - F_f^{U,e} - F_f^e)}{p_E^e}, 0\right] + E_{-1}^s \qquad (\Delta E^s = E^s - E_{-1}^s) \tag{38}$$

$$\Delta L_f^d = I_A - (F^U + F_f + p_E.\Delta E^s) \tag{39}$$

$$L_f = L_{f,-1} + \Delta L_f^s \tag{40}$$

capital gains:

$$CG_{f,E} = \Delta p_e \cdot E_{f,-1} \quad CG_{f,O} = \Delta p_O \cdot O_{f,-1}$$

$$CG_f = CG_{f,E} + CG_{f,O} \tag{41}$$

balancing:

$$A_f = A_{f,-1} - \delta_k.K_{-1} + F^U + F_f + \Delta L_f + p_E.\Delta E^s + CG_f \tag{42}$$

$$D_f = A_f - K - p_E.E_f - p_O.O_f \tag{43}$$

$$V_f = A_f - E^s - L_f \tag{44}$$

3.6.5 Banks

Decisions: 1) loans, 2) profits, 3) interest rates, 4) PC

Loan provision: Banks' loan provision to households, equation (45), depends on their capital adequacy ratio (CAR), equation (46) (defined according to Basel rules), and banks' assessment of households' creditworthiness, which rises with capital gains, see equation (45). We assume households to take up all loans supplied by banks, see equation (8).

For firms and the OFI sector, we assume all loans that are demanded are also supplied (demand accommodation), equations (39), (**??**). [A mechanism similar as for households to constrain credit to OFIs and firms is also an option.]

$$\frac{\Delta L_h^s}{V_h^e} = \tau_1 CG_h^e + \tau_2 (CAR_t - MCAR_t) \tag{45}$$

$$CAR = \frac{L^s}{A_b(\text{Basel risk-weighted})} \tag{46}$$

$$\Delta L_o^s = \Delta L_o^d \qquad \text{or similar as for } h \tag{47}$$

$$\Delta L_f^s = \Delta L_f^d \qquad \text{or similar as for } h \tag{48}$$

$$\Delta L^s = \Delta L_f^s + \Delta L_{ofi}^s + \Delta L_h^s \tag{49}$$

cash flow/profits:

$$\Pi_b = F_b + i_L.L_{-1}^s - i_D.D_{-1}^s + i_O.O_{b,-1} + i_B.B_{b,-1} \tag{50}$$

$$FB^U = \xi_b.\Pi_b, \tag{51}$$

$$FB^D = (1 - \xi_b).\Pi_b \tag{52}$$

$$\xi_b \perp CAR = \mu_{CAR} + MCAR \tag{53}$$

$$i_D = i_A.(1 + \sigma_D) \tag{54}$$

$$i_L = i_D.(1 + \mu_L) \tag{55}$$

Here, μ_{CAR} is a margin of safety over the marginal capital adequacy ration ($MCAR$) set by the regulator, which is applied by the banks to determine their holdings of equity capital. Interest rates set by banks (deposit interest rates paid, interest rates on loans charged) are chosen according to fixed markups on the policy rate set by the central bank. Again, here deposits (which include repo loans according to national accounting conventions) are assumed to be the buffer stock.

portfolio choice:

$$[D_b^d = (\lambda_b^{10} - \lambda_b^{11}.r_E^e - \lambda_b^{12}.r_B^e - \lambda_b^{13}.r_O^e).DA_b^e] \qquad \text{(bank deposits = repos are buffer stock)}$$

$$E_b^d.p_e = (\lambda_b^{20} + \lambda_b^{21}.r_E^e - \lambda_b^{22}.r_B^e - \lambda_b^{23}.r_O^e).DA_b^e \tag{56}$$

$$B_b^d.p_b = (\lambda_b^{30} - \lambda_b^{31}.r_E^e + \lambda_b^{32}.r_B^e - \lambda_b^{33}.r_O^e).DA_b^e \tag{57}$$

$$O_b^d.p_O = (\lambda_b^{40} - \lambda_b^{41}.r_E^e - \lambda_b^{42}.r_B^e + \lambda_b^{43}.r_O^e).DA_b^e \tag{58}$$

$$DA_b^e = DA_{b,-1} + FB^{U,e} + CG_b^e \tag{59}$$

Reserves:

$$R^{req} = D^s.drr \tag{60}$$

$$R^{adv} = Adv^s \qquad (Adv^s = max\{(R^{req} - R^{QE}), 0\}) \tag{61}$$

$$R_b = R^{adv} + R^{QE} \tag{62}$$

$$R^{exc} = R_b - R^{req} \tag{63}$$

drr is the deposit-reserves ratio (exogenous).

capital gains:

$$CG_{b,E} = \Delta p_e \cdot E_{b,-1} \quad CG_{b,B} = \Delta p_b \cdot B_{b,-1}$$

$$CG_{b,O} = \Delta p_O \cdot OFI_{b,-1}$$

$$CG_b = CG_{b,E} + CG_{b,B} + CG_{b,O} \tag{64}$$

balancing:

$$L^s = L_h + L_f + L_o \qquad (\Delta L^s = L^s - L^s_{-1}) \tag{65}$$

$$D^s = D_h + D_f + D_o + D_b \qquad (\Delta D^s = D^s - D^s_{-1}) \tag{66}$$

$$DA_b = DA_{b,-1} + FB^U + CG_b - \Delta R^{QE} \tag{67}$$

$$D_b = DA_b - p_E E_b - p_B B_b - p_O O_b \tag{68}$$

$$A_b = A_{b,-1} + FB^U + \Delta L^s + \Delta R_b + CG_b \tag{69}$$

$$V_b = A_b - D^s - Adv^s \tag{70}$$

3.6.6 OFIs (work in progress)

Decision: 1) interest rate (dist.profits), 2) O^s emissions, 3) loans/leverage, 4) PC

cashflow/profits:

$$\Pi_o = F_o + p_O.\Delta O^s + i_D.D_{o,-1} + i_B.B_{o,-1} - i_{L_o}.L_{o,-1} + CG_o \tag{71}$$

$$i_{L_o} < i_{L_h} \quad \text{(Possibility (work in progress) banks lend chaep to ofis - repo loans)} \tag{72}$$

$$i_O = \mu_{i_O} + i_D \tag{73}$$

$$F_o^D = i_O.O^s \tag{74}$$

$$F_o^U = \Pi_o - F_o^D \tag{75}$$

issuance and return-rate decisions:

$$O^s \quad \perp \quad p_O - p_{O,-1} \geq 0 \tag{76}$$

OFIs could issue such an amount of shares so that the price of OFI shares does not fall. OFIs seek to control the price in such a way as to avoid disinvestment by other agents in their shares due to falling returns. Implicitly, we thus assume that the OFI sector hinges more on speculative motives than other sectors in the issuance of its liabilities, while other sectors rather have a concrete financing decision or financing needs that will determine the amount of liabilities they emit.

leverage decision: In case of gearing with bank loans (repos):

Work in progress: Potentially, OFIs could leverage so that OFI shares offer a larger return rate by the margin μ_o over the economy-wide return rate $\overline{r}_{TOT}$.

$$\Delta L_o \perp r_o > \overline{r}_{TOT} + \mu_o \tag{77}$$

portfolio decision: The Ofi sector has rational expectations, and knows stock market outcomes.

$$[D_o^d = (\lambda_o^{10} + \lambda_o^{11}.i_D - \lambda_o^{12}.r_E - \lambda_o^{13}.r_B).A_o] \quad \text{Deposits are buffer stock}$$

$$E_o^d.p_E = (\lambda_o^{20} - \lambda_o^{21}.i_D + \lambda_o^{22}.r_E - \lambda_o^{23}.r_B).A_o \tag{78}$$

$$B_o^d.p_B = (\lambda_o^{30} - \lambda_o^{31}.i_D - \lambda_o^{32}.r_E + \lambda_o^{33}.r_B).A_o \tag{79}$$

$$A_o = A_{o,-1} + F_o^U + \Delta L_o \tag{80}$$

Capital gains:

$$CG_{o,E} = \Delta p_e \cdot E_{o,-1} \quad CG_{o,B} = \Delta p_b \cdot B_{o,-1}$$

$$CG_o = CG_{o,E} + CG_{o,B} \tag{81}$$

balancing:

$$D_o = A_o - E_o.p_e - B^d_o.p_b \tag{82}$$
$$V_o = A_o - p_O.O^s - L_o \tag{83}$$

3.6.7 Central Bank

cashflow/profits:

$$\Pi_{cb} = F_{cb} + i_O.O_{cb,-1} + +i_B.B_{cb,-1} + i_A.Adv^s_{-1} \tag{84}$$

QE and portfolio decision:

$$\Delta R^{QE} = exogenous \text{ (data)} \tag{85}$$
$$R^{QE} = R^{QE}_{-1} + \Delta R^{QE} \tag{86}$$
$$Adv^s = R^{req} - R^{QE} \tag{87}$$
$$E^d_{cb}.p_E = (\lambda^{10}_{cb} + \lambda^{11}_{cb}.r^e_E - \lambda^{12}_{cb}.r^e_B - \lambda^{13}_{cb}.r^e_O).R^{QE} \tag{88}$$
$$B^d_{cb}.p_B = (\lambda^{20}_{cb} - \lambda^{21}_{cb}.r^e_E + \lambda^{22}_{cb}.r^e_B - \lambda^{23}_{cb}.r^e_O).R^{QE} \tag{89}$$
$$O^d_{cb}.p_O = (\lambda^{30}_{cb} - \lambda^{31}_{cb}.r^e_E - \lambda^{32}_{cb}.r^e_B + \lambda^{33}_{cb}.r^e_O).R^{QE} \tag{90}$$

interest rate:

$$i_A = exogenous \text{ (data)} \tag{91}$$
$$Adv^s = R^{req} - R^{QE} \tag{92}$$

capital gains:

$$CG_{cb,E} = \Delta p_e \cdot E_{cb,-1} \quad CG_{cb,b} = \Delta p_b \cdot B_{cb,-1}$$
$$CG_{cb,O} = \Delta p_O \cdot O_{cb,-1}$$
$$CG_{cb} = CG_{cb,E} + CG_{cb,B} + CG_{cb,O} \tag{93}$$

balancing:

$$p_B.B_{cb} = R^{QE} - p_E.E_{cb} - p_O.O_{cb} \tag{94}$$
$$V_{cb} = Adv^s + p_E.E_{cb} + p_O.O_{cb} + p_B.B_{cb} - R_b + CG_{cb} \tag{95}$$

Here (89) and (94) yield the same result, only one is used in the model. This is because the CB does not expect, but *knows* how much it invests. This is because capital gains are paid to government completely. Thus, also (95) should be zero always.

Maybe change this, and introduce a time lag: cb pays last years CG to govt, then has an expected disposable assets DA^e_{cb} (including this years CG) in the PC, and Bonds as buffer stock, just as banks. Then V_{cb} would be positive too.

3.6.8 Government

spending and taxation decision:

$$G = exogenous \tag{96}$$

$$T = \theta.Y_h \tag{97}$$

$$\Pi_g = T - G + \Pi_{cb} - i_B.B_{-1} \tag{98}$$

refinancing:

$$p_B \Delta B^s = -\Pi_g \tag{99}$$

$$i_B = \frac{i_{B,-1}.B^s_{-1}}{p_B.B^s} \qquad \text{a form of perpetuity} \tag{100}$$

We model bonds as a form of perpetuity with variable price and interest rate. The interest rate is determined by the market price for bonds p_B, which equilibrates the nominal demand for and nominal supply of bonds. The price actually only exists - apart from giving agents the possibility to value their bonds on the asset side of their balance sheets - so that the bond interest rate can be determined. The value of all bonds is the expected infinite future revenue stream discounted by the interest rate. In a steady state, this would be represented by

$$p_B.B^s = \sum \frac{i_B.B^s}{(1-i_B)^t} = \sum \frac{i_{B,-1}.B^s_{-1}}{(1-i_B)^t} \tag{101}$$

We assume that the government uses the right hand side of this formula to update the interest rate after the market price was determined. Some algebra yields equation (100).

balancing:

$$B^s = B^s_{-1} + \Delta B^s \tag{102}$$

$$V_g = -B^s \tag{103}$$

4 Calibration and Simulations (preliminary work in progress!)

4.1 Data and Calibration

4.1.1 Calibration Strategy

In the final model version, we intend not to use a steady state (same growth rates for all variables), but: an endogenous, "data-driven" dynamic, cf. Kinsella and Aliti (2012), that adheres to a model-consistent aggregation of the National Annual Sectoral Accounts (**NASA**).

We have constructed the **BSM and TFM matrices** for **1995-2016** (Data for all variables) (ESA 2010, Eurostat (2013)).

We use NASA data to...

- ... estimate some parameter values (consumption, investment, return rates, portfolio choice,...) over the total time period or particular time periods (before-after financial crisis 2007/2008, etc.)
- ... calculate some parameter values for “average” TFM and BS matrices 2010 - 2016 (“after-crisis EA economy”)

Calibrated to average TFM and BS matrix, we can use this model to conduct scenario analysis

Our explicit aim is to consistently **calibrate this SFC model for the Euro Area (EA)**.

- Calibrate to EA national accounting data consistently.

Main the main **research questions** for the calibration process include:

- How well does the theoretical model developed before explain run-up to financial crisis 2008/2008 for EA. And the great recession thereafter?
- What macroprudential policies (on a macro level) are viable to alleviate build up and burst of credit-fuelled asset price bubbles?
- At later stages of the model building process, we also intend to assess viability of this model as a forecasting tool?

4.2 Data (preliminary and incomplete)

- NASA (Eurostat, 2013) data include assets, liabilities, net worth, financial and non-financial transactions of and between all agents,
- in a much finer disaggregation than necessary for our model (we need to aggregate consistently)
- for all EU countries, 1995-2014.

As explained in section 4.2.1 below, the data have to be brought to the aggregation of the model in order to be useful for us. To show the structure of the data, figures 3 and 4 show net lending and net borrowing for 1995 - 2016 for different sectoral aggregations – the sectors of the full model version including the OFI sector and still with the rest of world (RoW) agent in figure 3, and the sectors of the reduced model version (no OFI sector, no RoW) in figure 4.

The interested viewer will certainly observe in both figures the large impact on the financial crisis 2007/2008. At first glance and according to intuition, mostly deteriorating government finances ("rescue packages" and similar Keynesian stimulus measures) and increasing the amount of savings by NFC sector for the euro area.

Figure 3: Net lending and net borrowing (NLNB) in the EA according to all sectors of the model + Rest of World (ROW), 1995 - 2016

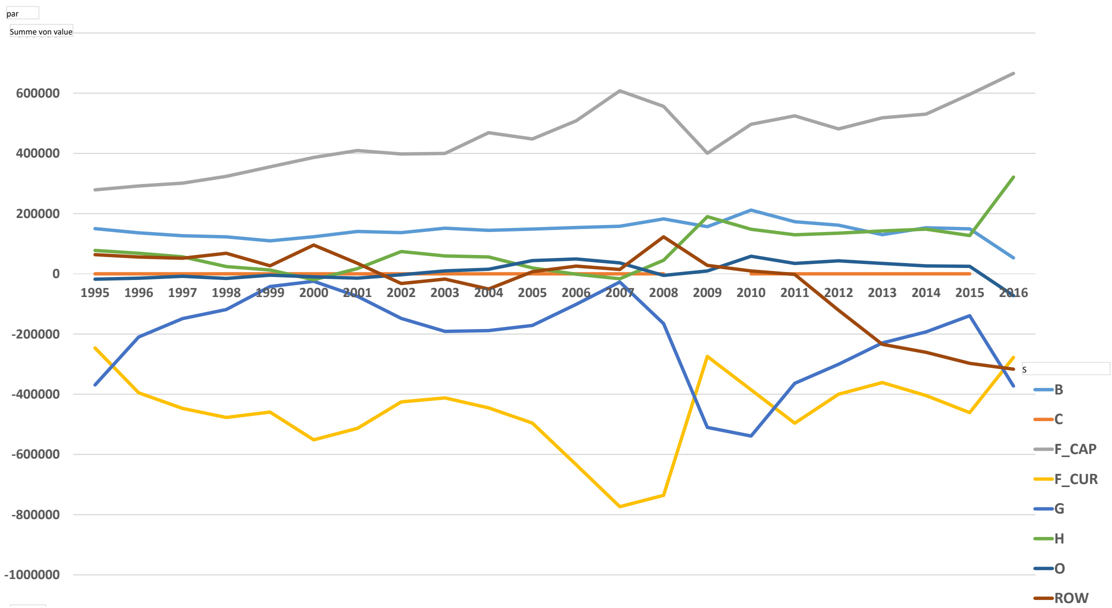
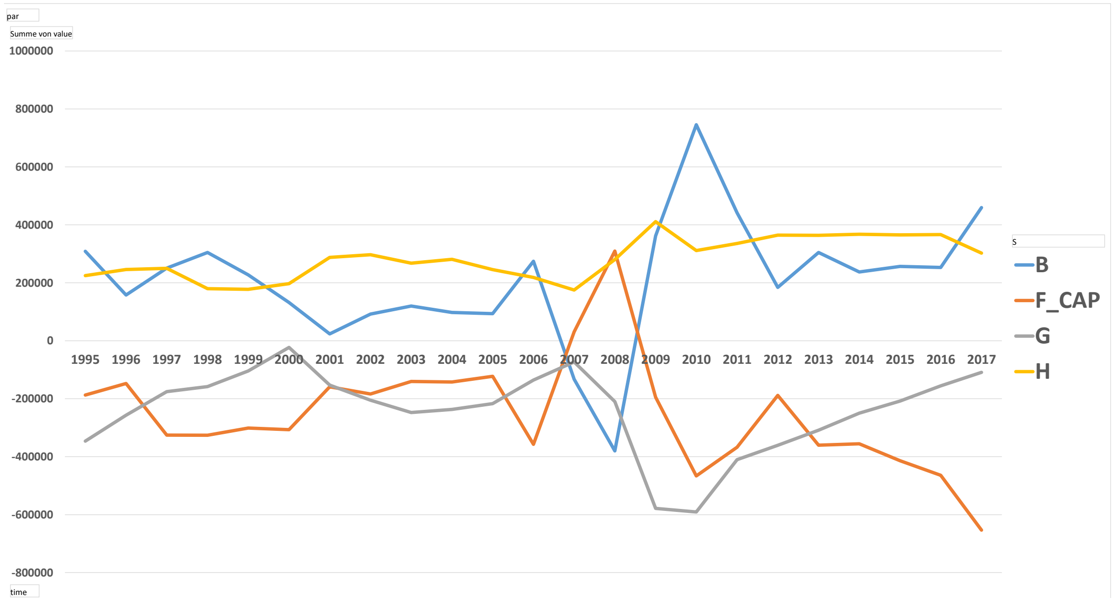


Figure 4: Net lending and net borrowing (NLNB) in the EA according to simplified version of model (no OFI), 1995 - 2016



4.2.1 Transaction Flow, Balance Sheet and Flow of Fund Matrices from the Data

TFM Table 3 below shows the full transaction flow matrix (TFM)

Table 3: Data: Non-financial transactions EA **2015** in million Euro, non-consolidated

in million Euro		S11 RECV	S11 PAID	S12 RECV	S12 PAID	S13 RECV	S13 PAID	S14_S15 RECV	S14_S15 PAID	S2 RECV	S2 PAID
wages	D11	-	2,559,808	-	175,344	-	748,240	3,851,300	351,375	34,674	51,207
social cont.	D12	-	672,833	-	58,249	-	286,865	1,099,891	78,435	7,137	10,646
vat on products	D211	-	-	-	-	699,753	-	-	651,591	34	-
imp tax on products	D212	-	42,753	-	-	34,279	-	-	-	16,611	-
tax on products (other)	D214	-	351,614	-	-	367,134	-	-	-	582	-
other tax on production	D29	-	125,683	-	28,752	240,829	23,488	-	67,113	-	-
subsidies on products	D31	65,381	-	-	-	-	63,854	-	-	-	2,542
other subs production	D39	91,073	-	1,547	-	5,139	93,563	23,915	-	-	28,110
Net interest payments	D41	144,783	191,728	763,456	533,501	30,161	239,000	123,839	72,427	416,728	443,797
distr. Income of corporations	D42	402,643	942,836	395,087	271,188	39,171	-	502,722	-	370,765	495,562
reinvested earnings fdi	D43	34,818	87,991	2,761	34,106	33	-	30	11	122,796	37,667
other inv. Income to insurance holders	D441	4,136	-	5,468	146,116	130	-	131,119	-	-	4,294
to pension holders	D442	-	262	-	55,522	-	1	55,743	-	51	9
to IF shareholders	D443	8,402	-	92,733	229,239	3,302	-	44,504	-	122,865	42,564
Rents	D45	724	16,982	-	1	16,243	246	8,774	8,500	-	-
income tax	D51	-	197,526	-	51,032	1,231,024	1,749	-	961,092	8,771	27,209
other current taxes	D59	-	2,609	-	1,291	72,644	66	-	68,496	6	138
employers actual sc	D611	32,683	-	80,229	-	825,268	-	1,746	942,062	9,496	7,125
employers imputed sc	D612	37,344	-	5,290	-	110,701	-	1,910	155,848	729	37
hh actual sc	D613	187	-	104,151	-	642,296	-	29	746,496	5,642	5,538
hh sc supplements	D614	262	-	68,670	-	-	-	-	68,898	-	34
social transfers in cash	D62	-	63,798	-	155,333	-	1,756,241	1,968,843	3,663	25,478	16,275
non life ins. Premiums	D71	-	42,462	269,501	51,783	10	2,851	-	143,399	26,132	55,147
non life ins. Claims	D72	36,458	-	50,854	267,093	1,847	10	143,725	-	55,064	20,845
current internaltional cooperation	D74	-	-	-	-	8,673	21,590	-	-	21,590	8,673
misc. Current trfs	D75	17,923	75,368	8,090	11,335	72,015	127,295	273,493	189,837	66,016	33,805
EU own resources	D76	-	-	-	-	-	87,898	-	-	87,898	-
pension enttlmts adjustments	D8	-	6,382	-	77,132	- -	47	84,132	497	- 165	2
capital taxes	D91	-	121,525	-	1,149	32,633	-	-	30,074	268	137
investment grants	D92	60,115	-	389	-	18,183	73,886	14,088	-	6,766	25,452
other capital trfs	D99	19,612	4,165	19,621	13,374	- 2,948	44,206	32,144	13,558	11,067	4,236
consumption (net of taxes!) + Cons. Fix. Cap. + NET VA from own production	P3	3,317,938	-	459,677	-	1,331,386	2,136,555	1,996,010	4,968,456	-	-
gross investment	P51G	2,088,346	1,224,235	-	54,733	-	277,116	-	532,262	-	-
ch. Inventories	P52	25,459	24,211	-	-	- -	63	-	1,311	-	-
acquis./disp. of valuables	P53	128,411	548	-	-	-	49	-	7,498	-	-
Exports	P6	2,936,307	-	-	-	-	-	-	-	-	2,936,307
Imports	P7	-	2,533,079	-	-	-	-	-	-	2,533,079	-
	B9	160,561	**160,561**	**89,517**	**89,517**	**- 205,486**	**- 205,486**	**319,318**	**319,318**	**- 360,070**	**- 360,070**

This matrix has already undergone numerous transformation processes to forge a consistent TFM from national accounting data according to the methodology developed in Miess and Schmelzer (2016)[8]. The the most important procedure in this regard is to consistently mix the distributive transactions (D) accounts with the production (P) accounts. Crucially, the matrix is made consistent with the line P3, where net consumption (P3 in NASA nomenclature) is added to net value added generated in a sector, so that net final consumption in the household and government sectors is attributed as a payment flow generating net value added in the non-financial corporations (NFC), financial corporations (FC), and well as in the household and government sectors itself.[9]

From this large matrix, after consolidation, and according to the principle of quadruple entry bookkeeping and under the main premise of preserving the (in the model) highly

[8]See `https://emedien.arbeiterkammer.at/viewer/resolver?urn=urn:nbn:at:at-akw:g-1522902`, Chapter 2.2, pp. 8-26.

[9]For further details, please see (Miess and Schmelzer, 2016, pp. 9 - 11).

influential data on net lending net borrowing (NLNB) of a certain sector (or an aggregated set of sectors), by aggregating sectors, assets, and booking certain entries according to the logic of the model to and from certain sectors, we arrive at ever smaller matrices of the model as they are given below.

Table 4: TFM EA 2015 in model aggregation, million Euro, consolidated, with residual

in million EUR	F_CUR	F_CAP	B	O	H	G	C	ROW
G	3,005,602	-	-	-	-	-3,071,048	-	85,375
C	4,523,232	-	-	-	-4,118,188	-	-	-
W	-7,476,678	-	-	-	7,476,678	-	-	-
T	-	-	-	-	-3,451,641	3,451,641	-	-
I	993,222	-993,222	-	-	-	-	-	-
int_D	17,586	-	-91,756	16,124	65,457	-	-11,173	3,762
int_B	-6,433	-	7,985	6,506	28,032	-51,773	8,928	6,755
int_O	8,325	-	-15,596	-145,630	94,984	-	565	57,353
int_L	-83,936	-	185,505	2,726	-96,766	-	1,387	-8,916
FD	-1,030,827	437,461	73,106	97,329	467,722	-	-5,123	-39,668
FU	-158,559	158,559	-	-	-	-	-	-
Fb	-	-	-42,615	-	42,615	-	-	-
Fcb	-	-	-	-	-	-5,417	5,417	-
res	283,575	397,202	-149,536	128,316	-143,676	-531,414	4,719	-414,169
NLNB TFM		75,109	-32,906	105,371	365,219	-208,011	4,719	-309,509

Legend: G - government consumption, C - household consumption, W - wages, T - taxes, I - investment, int_D - interest on deposits, int_B - interest on bonds, int_O - interest on OFI shares, int_L - interest on loans, FD - profits distributed by firms, FU - undistributed firm profits, Fb - bank profits, Fcb - central bank profits, res - residual to match non-financial transactions account with flow of funds (financial transactions).

Table 5: TFM EA 2015 in model aggregation without OFI sector, million Euro, no residual and OFI sector

in million Euro	F_CUR	F_CAP	B	H	G
G	3,264,805				-3,264,805
C	4,523,232			-4,523,232	
W	-7,476,678			7,476,678	
T				-3,108,568	3,108,568
I	993,222	-993,222			
int_D	28,118		-91,756	63,638	
int_B			21,947	29,826	-51,773
int_L	-98,547		185,505	-86,958	
FD	-1,367,192	712,432	45,647	609,113	
FU	133,040	-133,040			
Fb			95,280	-95,280	
res	-0	0		-0	0
nlnb		-413,830	256,623	365,218	-208,011

BSM and FoF matrices A similar procedure is applied to the BSM and FoF matrices, where less conditions have to be respected than for the TFM. For example, these data are already stock-flow consistent, in difference to the non-financial transactions data underlying the TFM. Naturally, the same set of procedures is applied both to the BSM and FoF matrices.

Table 6: Balance Sheet Matrix from NASA data (Euro Area, 2017) in billion Euro, non-consolidated

billion of Euro		F_CUR ass	F_CUR liab	F_CAP ass	B ass	B liab	O ass	O liab	H ass	H liab	G ass	G liab	C ass	C liab	ROW ass	ROW liab
Financial Net Worth	**BF90**	0	-10252	0	0	1061	0	-128	0	16645	0	-7650	0	204	0	258
Monetary gold, special drawing rights	**F1**	-	-	-	-	-	-	-	-	-	-	- 1	-	- 58	59	0
Currency and Deposits	**F2**	2,409	- 45	-	8,043	- 19,751	2,020	- 0	8,354	-	867	- 510	2,174	- 4,252	6,820	-6,129
Debt Securities	**F3F6F8**	4,668	- 5,753	-	6,681	- 5,364	5,808	- 4,475	13,531	- 9,172	1,356	- 9,787	2,174	- 46	12,313	-11,936
Loans, other accounts	**F4**	4,506	- 9,790	-	12,882	- 378	6,380	- 6,326	619	- 6,483	1,014	- 2,343	76	- 0	7,904	-8,060
FIRM EQUITY	**F51**	-	- 18,428	11,774	1,448	- 1,680	14,535	- 10,076	5,387	- 697	1,656	- 106	21	- 243	14,029	-17,621
OFI SHARES (IFU + MMMF Shares or units) + Derivatives	**F52F7**	488	- 80	-	1,873	- 2,693	2,821	- 10,685	5,112	- 8	242	- 38	27	- 1	7,564	-4,624
HOUSES	**H**	1,797	-	-	108	-	-	-	13,116	-	179	-	-	-	-	0
REAL CAPITAL STOCK	**K**	10,706	-	-	525	-	-	-	14,756	-	4,745	-	-	-	-	0

Table 7: Balance Sheet Matrix from NASA data (Euro Area, 2017) in million Euro, consolidated

	0	F_CUR	F_CAP	B	O	H	G	C	ROW
FINANCIAL NW DATA	**BF90**	**- 10,252,370**	**-**	**1,061,109**	**- 128,158**	**16,644,684**	**- 7,649,651**	**203,733**	**257,939**
Monetary gold, special drawing rights	**F1**	0	0	0	0	0	-1,152	-57,623	58,774
Currency and Deposits	**F2**	2,363,782	0	-11,707,971	2,019,624	8,354,188	356,829	-2,077,660	691,208
Debt Securities	**F3F6F8**	-1,085,593	0	1,316,905	1,333,844	4,359,836	-8,430,384	2,128,261	377,139
Loans, other accounts	**F4**	-5,284,551	0	12,503,332	54,381	-5,864,282	-1,329,132	75,928	-155,673
FIRM EQUITY	**F51**	-18,428,241	11,773,943	-231,430	4,459,304	4,690,516	1,550,364	-221,785	-3,592,671
OFI SHARES (IFU + MMMF Shares or units) + Derivatives	**F52F7**	408,292	0	-819,724	-7,863,283	5,104,428	203,823	26,327	2,940,136
HOUSES	**H**	1,797,001	0	108,199	0	13,115,778	179,294	0	0
REAL CAPITAL STOCK	**K**	10,706,351	-	525,193	-	14,755,629	4,745,347	-	-
FINANCIAL NW	**FIN NW**	**-10,252,368**		**1,061,111**	**3,869**	**16,644,685**	**-7,649,651**	**-126,552**	**318,914**

Table 8: Balance Sheet Matrix from NASA data (Euro Area, 2017) in million Euro, consolidated (cleaned to fit structure of theoretical model)

in millions of Euro		**F_CUR**	**F_CAP**	**B**	**O**	**H**	**G**	**C**	**ROW**
Repos Assets	**Ra**	**-**	**-**	**8,654,402**	**-**	**-**	**-**	**-**	**-**
Repos Liabilities	**Rl**	-	-	- 8,654,402	-	-	-	-	-
Deposits	**D**	2,541,370	-	- 11,511,498	1,923,062	8,546,224	-	- 2,719,808	1,220,644
Bonds	**B**	-	-	- 893,950	1,812,793	4,285,071	- 7,542,981	2,733,467	- 394,400
Equities	**E**	- 20,856,851	12,547,376	1,484,787	4,994,560	4,953,616	-	- 212,554	- 2,910,936
Ofis	**O**	449,855	-	- 816,607	- 8,756,301	5,590,809	-	30,085	3,502,156
houses	**H**	-	-	-	-	14,930,406	-	-	-
capital	**K**	30,007,706	-	-	-	-	-	-	-
Loans	**L**	- 5,312,478	-	12,590,323	- 124,904	- 5,997,120	-	53,963	- 1,209,788
FINANCIAL NW	**V**	- 23,178,103	12,547,376	853,056	- 150,790	17,378,598	- 7,542,981	- 114,846	207,676

Table 9: Balance Sheet Matrix from NASA data (Euro Area, 2017) in million Euro, consolidated, final version without OFIs

		F_CUR	F_CAP	B	H	G
Repos Assets	**Ra**	**-**	**-**	**8,654,402**	**-**	**-**
Repos Liabilities	**Rl**	-	-	- 8,654,402	-	-
Deposits	**D**	2,965,269	-	- 11,511,493	8,546,224	-
Bonds	**B**	-	-	3,257,910	4,285,071	- 7,542,981
Equities	**E**	- 23,759,981	12,547,376	668,180	10,544,424	-
houses	**H**	-	-	-	14,930,406	-
capital	**K**	30,007,706	-	-	-	-
Loans	**L**	- 6,593,206	-	12,590,326	- 5,997,120	-
Total NLNB incl. Real capital	**V**	**- 27,387,918**	**12,547,376**	**5,004,924**	**17,378,598**	**- 7,542,981**

Table 10: Flow of Funds Matrix from NASA data (Euro Area, **2015**) in million Euro, consolidated, with OFIs

in million Euro		**F_CUR**	**F_CAP**	**B**	**O**	**H**	**G**	**C**	**ROW**
Repos Assets	**Ra**	**-**	**-**	**11,115**	**-**	**-**	**-**	**-**	**-**
Repos Liabilities	**Rl**	-	-	- 11,115	-	-	-	-	-
Deposits	**D**	139,268	-	**130,729**	44,271	167,704	-	- **581,281**	99,312
Bonds	**B**	-	-	**11,226**	210,101	- 92,747	- 208,011	**517,652**	- 438,221
Equities	**E**	- 565,895	395,614	- 17,582	376,462	62,865	-	709	- 252,168
Ofis	**O**	44,761	-	- 106,925	- 437,406	304,061	-	981	194,528
houses	**H**	-	-	-	-	213,661	-	-	-
capital	**K**	388,825	-	-	-	-	-	-	-
Loans	**L**	61,365	-	- **50,356**	- 88,054	- 76,665	-	66,663	87,047
NLNB	**V**	**- 320,502**	**395,614**	**- 32,910**	**105,374**	**365,218**	**- 208,011**	**4,723**	**- 309,502**

4.3 First Results from Steady State Calibration

PRELIMINARY AND INCOMPLETE!

Table 11: First Results from Steady State Calibration: NLNB, 1995 - 2002

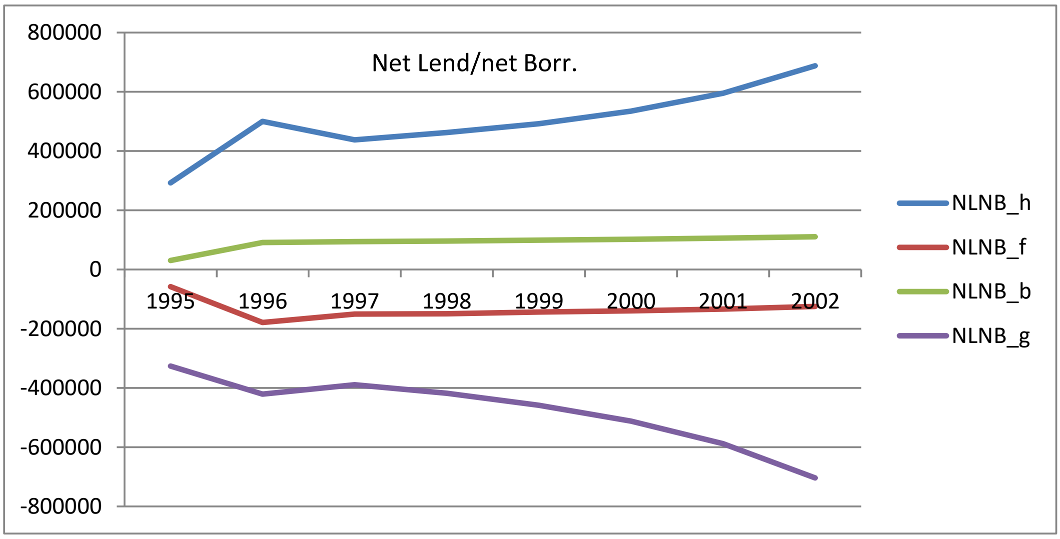


Table 12: First Results from Steady State Calibration: Prices, 1995 - 2002

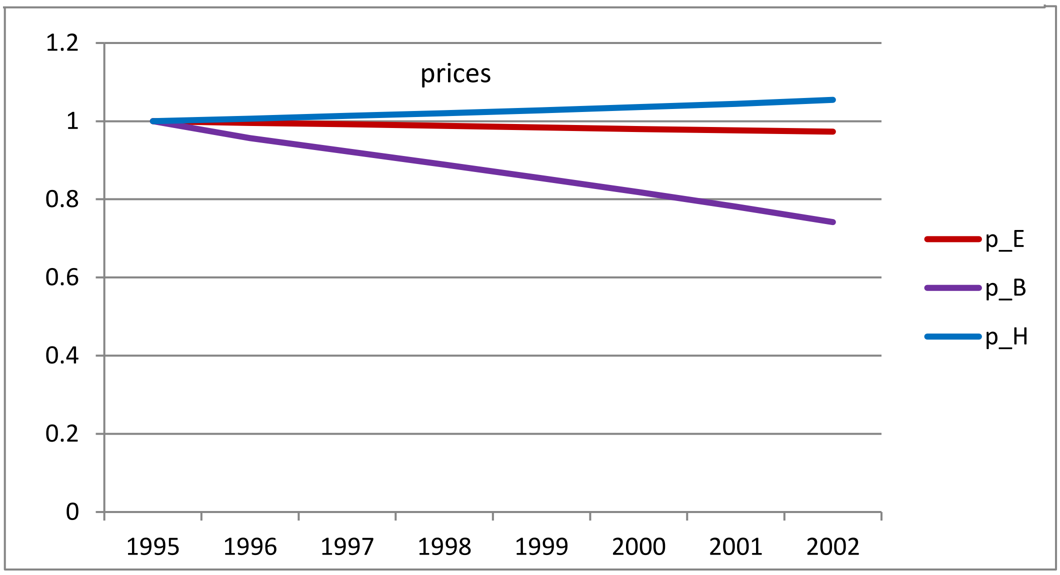


Table 13: Steady State Calibration: Change bond holdings, 1995 - 2002

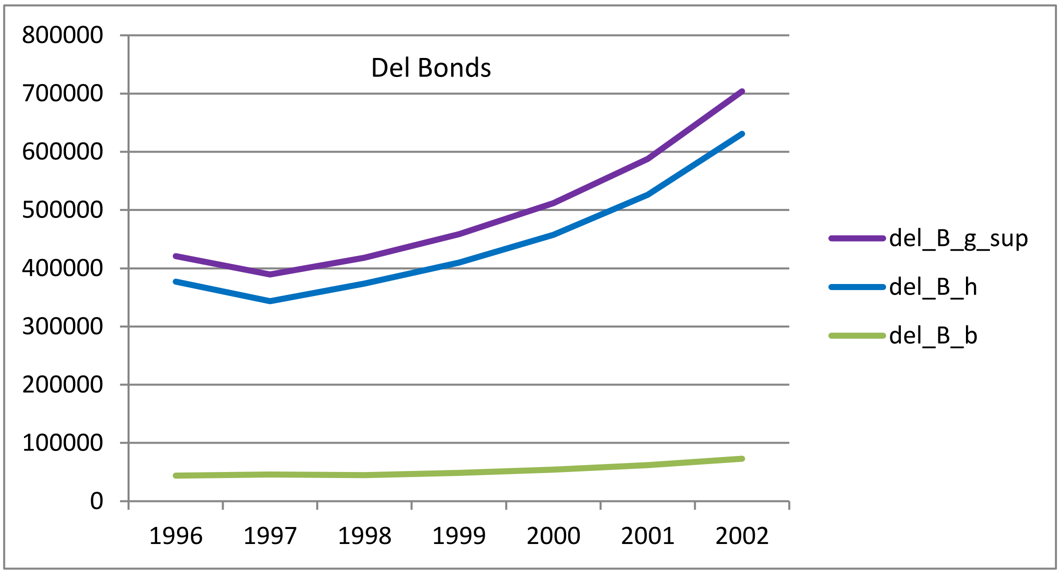


Table 14: First Results from Steady State Calibration: Household Sector, 1995 - 2002

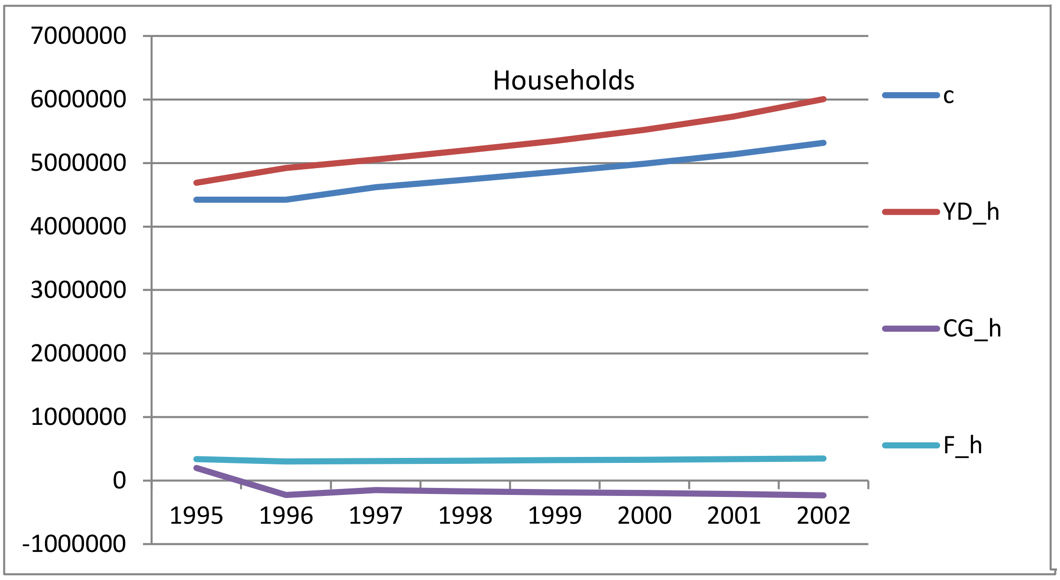
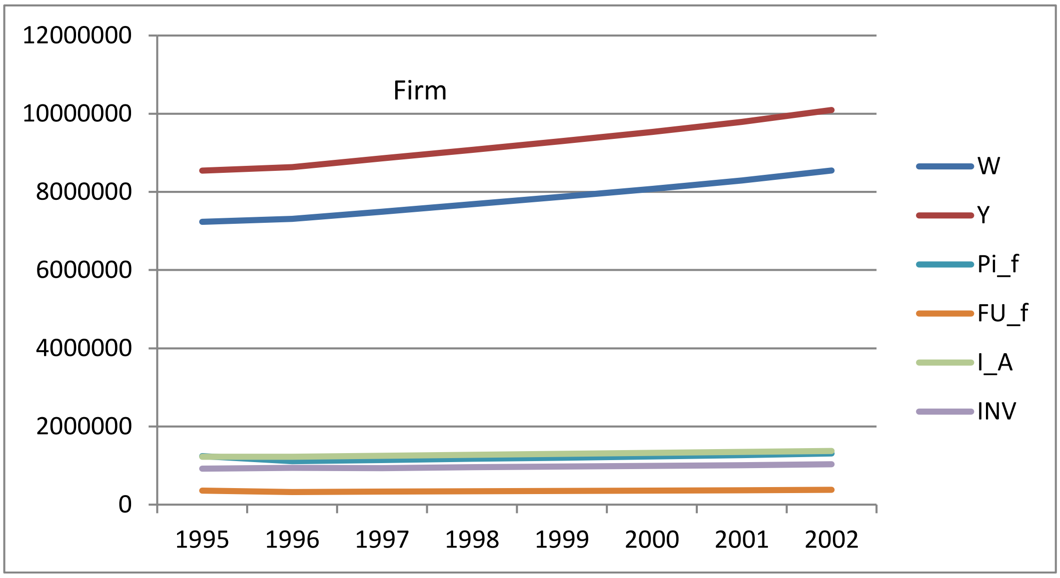


Table 15: First Results from Steady State Calibration: Firm Sector, 1995 - 2002



5 Conclusion and Further Research (incomplete work in progress)

Real-Financial Cycles SFC Model:

- Novel way for endogenous depiction of real-financial cycles on empirical basis.
- Calibrated to EA data with "endogenous dynamics" (in final model version).
- Policy perspective (e.g. macroprudential regulation).

Further research: ABM-SFC with big (micro-) data on supercomputers

- connect to another research agenda started e.g. in Miess (2019) of simulating agent-based models (ABMs) on supercomputers using big data → this SFC model could lead the way for a novel approach to depict endogenous financial cycles, fundamental uncertainty, and network effects on an empirical basis. We have already applied for funding for this research agenda.

Empirical (ABM-)SFC Model: Advantages as Forecasting Tool -

- Consideration of stocks and flows in a monetary production economy
- Model explains growth and dynamics of assets and liabilities
- different agents and behaviours;
- endogenous dynamics;
- calibrated to National Accounting data and derived trends
- highly flexible, many scenarios possible.

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