# Bank credit and money creation in a DSGE model of a small open economy

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**ABSTRACT**

By the act of lending banks do not actually intermediate pre-accumulated real resources but rather create new financial resources in the form of deposits. Therefore, bank credit needs to be modelled as a monetary phenomenon, which directly fuels domestic demand and inflationary pressures. So far, there have been just a few attempts to model banks as monetary institutions in the DSGE model. In this paper we propose a simple DSGE model, which nevertheless accommodates banks as genuinely monetary institutions and captures banks' institutional ability to create money. Our model features a small open economy with nominal prices, savers and borrowers and a banking sector. Following an exogenously induced shock to banker's willingness to lend, the bank does not have to raise deposit rates or significantly increase borrowing from abroad as deposit dynamics closely resembles that of credit, which allows us to analyse real and nominal consequences of bank credit (and money) creation.

## 1. Introduction

There has been a long-standing debate among economists about the macroeconomic role of banks and the relationship between money and bank credit. The popular 'deposits first' view on credit, 'intermediation of loanable funds', maintains that banks simply intermediate loanable resources from savers to borrowers. The opposing 'credit first' view, otherwise referred to as 'financing through money creation', claims that banks do not intermediate real resources but rather create money and purchasing power at will, without the necessity to rely on pre-accumulated savings.

There are several points to note with regard to this debate. It is clear that at the institutional, or bank, level the 'credit first' paradigm gives a much more adequate description of the actual mechanism of credit and money creation at the moment of credit origination. It is well known that when a bank issues a loan, it simultaneously creates a matching deposit in the borrower's account, thereby creating new money (see McLeay, Radia, & Thomas, 2014). Thus, banks' ability to create money is determined by the institutional features of the banking system, namely, recognition of

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bank liabilities (deposits) as a means of payment (money) and banks' access to the central bank liquidity.

However, even though banks technically create money, this does not clearly prove the 'deposit first' view wrong in the broader macroeconomic context. One can argue that banks have no control over financial flows immediately after the loan origination – the newly created money can flow out of the loan-issuing bank; therefore, banks are in a constant need of ensuring their adequate liquidity positions and are forced to compete for retail deposits and other external financing – all of which potentially restrain the banks' ability to create new money 'at will'. If banks create money but at the same time are dependent on consumers' and businesses' 'saving', or their keeping that money in the banking system, the distinction between the two views might seem blurred and lacking practical relevance. In the macroeconomic setting, the more relevant question therefore concerns the actual limits to money creation, i.e. whether intermediation of savings or banks' money creation are more central for understanding the macroeconomic role of banks. The traditional intermediation-of-savings view is somewhat at odds with the so-called elasticity of the financial system, i.e. the ability and tendency of financial intermediaries, and banks in particular, to expand their balance sheets (grow loan portfolios) at a very fast pace and largely independently from real economic growth or accumulation of real resources (see Borio & Disyatat, 2011). The notion of financing through money creation naturally explains the elasticity of the financial system, as it suggests that bank credit can be at least partly self-financing, i.e. strong credit expansion does not necessarily put an upward pressure on deposit rates (because new deposits are created in the process) or necessitate equal financing from abroad.

Another major implication of the banks' ability to create money and purchasing power is the immediate contribution of a credit shock to aggregate demand, nominal incomes and price pressures. Viewing bank credit as a powerful monetary stimulus provides a compelling theoretical argument for the well-known empirical relationship between credit and business cycles (see Xu, 2012) or the prominent role of credit in the economic boom-and-bust cycles (Schularick & Taylor, 2012). In contrast, the traditional view of bank credit as intermediation of savings, or temporary reallocation of real resources, would suggest that bank credit would have a largely neutral immediate impact on aggregate demand, and the credit-related business cycle amplification would be explained largely through credit market frictions and financial accelerator effects. This explanation seems plausible but incomplete.

Empirical economists and policy makers have gradually recognized the role of financing through money creation in their analyses but there are surprisingly few attempts to explicitly model the principles of credit and money creation in standard models. Among those who raise these problems, the prevalent view is that banks in the mainstream New Keynesian (NK) or dynamic stochastic general equilibrium (DSGE) models are almost universally modelled as intermediaries of loanable funds and thus the true macroeconomic role of banks is misrepresented (Borio, 2012; Jakab & Kumhof, 2015).

Our main contribution to the literature is that we propose a simple and quite standard theoretical DSGE model with some relatively minor adjustments, which nevertheless accommodates banks as genuinely monetary institutions and captures banks' institutional ability to create money. In our model, the financial system possesses the elasticity property in the sense that bank credit can be created at will, without strong dependence on pre-accumulated resources, without putting the upward pressure on deposit rates or necessitating bank borrowing from abroad. Following the exogenously induced shock to banker's

willingness to lend, the deposit dynamics closely resembles that of credit, which is an indication of creation of deposits (and money) by the act of lending. A positive credit shock also induces significant pressures on aggregate (domestically financed) demand and prices, indicating that credit directly contributes to domestic demand rather than simply alters its composition.

A number of features of our model are important in ensuring that banks are modelled as monetary institutions. A model economy is a stock-flow consistent dynamic system, with endogenously determined money supply. A degree of sector heterogeneity is ensured to induce economically interesting borrowing and lending behaviour. Agents do not fully internalize the model economy, e.g. a producer of goods cannot distinguish a change in demand for his products related to a change in consumer preferences from a credit-induced increase in aggregate demand. Also, the financial system in the model possesses some realistic institutional features: a representative competitive bank has a separate balance sheet, dual-purpose deposits, which serve as both savings and transaction instruments, autonomous decision making power and, importantly, the ability to issue loans in nominal terms. Thus, in order to analyse banks as monetary institutions it is crucial to have prices and price identification mechanism in the model – in our case, price identification is based on the external competitiveness condition. We observe that in the fixed-price setting bank lending is effectively reduced to intermediation of loanable funds, since – simply put – banks cannot create real resources. In contrast, in the more realistic flexible-price environment (in which prices are determined in general equilibrium, though price rigidities are not ruled out), the bank does create new purchasing power by issuing new loans, in line with the FMC view.

The basic self-financing mechanism of bank credit in the model is as follows. Bank lending creates money and new purchasing power, which creates inflationary pressures and raises nominal incomes (depending on the magnitude of price adjustment costs, this monetary stimulus also induces an immediate increase in real economic activity and incomes). The newly created money is used to settle economic transactions and though part of it leaves the economy through the current and financial account, the bulk of it remains in the form of deposits. These deposits in turn serve as the main source of bank financing, thereby creating the financing feedback loop.

By contrasting model responses to household's and bank's preference shocks, we also distinguish between two very different forms of financing, namely, saving-based financing and bank credit-based financing, which often tend to be conflated by policy-makers and economists alike (see discussion in Borio & Disyatat, 2011). Finally, we apply the model, calibrated to the case of the Lithuanian economy, to specifically study the possible reaction of economic and financial variables to rise in the minimum bank capital requirement.

The rest of the paper is structured as follows. In Section 2 we provide a general discussion on the macroeconomic role of banks. In Section 3 we present a simple DSGE model of a small open economy, which is also a member of the monetary union and has a simple functional banking sector. Section 4 contains some technical details on calibrating the model to match the Lithuanian data. The basic analysis of system's responses to banker's preference, household's preference, capital requirement and risk-free interest rate shocks is presented in Section 5. Section 6 concludes.

## 2. Discussion on the macroeconomic role of banks

### 2.1. Banks in the mainstream economic analysis

According to the standard banking theory, banks are deposit-taking financial intermediaries that help allocate capital in the economy by offering liquidity and payment services, transforming assets, managing risks, processing information and monitoring borrowers (see Freixas & Rochet, 2008, p. 2). In simple terms, banks are seen as intermediaries between savers and borrowers, which can potentially improve efficiency of capital allocation by achieving economies of scale, alleviating asymmetric information problems and offering risk management expertize. The currently dominant NK macroeconomic paradigm, rooted in the neoclassical real business cycle (RBC) modelling tradition with some added market frictions and nominal rigidities, also embraces the standard view of banks as financial intermediaries between savers and borrowers. At its core, the NK analysis is real, in a sense that it tries to explain the real economy by focusing on real factors (Borio, 2012; Borio & Disyatat, 2011). Even intrinsically nominal (or monetary) variables, such as credit and money, are typically expressed and analysed in real terms. This gives rise to the 'intermediation of loanable funds' (ILF) or 'deposits first' view of banking intermediation, according to which banks first need to attract real resources from savers in the form of deposits and, conditional on this, are able to reallocate the resources to borrowers by extending new loans. Needless to say, the macroeconomic role of banks in this modelling approach is rather minor and vague. For decades, in the RBC models and early NK models banks weren't even part of the analysis as they were deemed essentially redundant from the macroeconomic perspective. Money and credit were regarded simply as a 'veil', i.e. inconsequential for understanding how the economy works.

Following the global financial crisis of 2008, there has been a growing consensus that financial intermediaries, and banks in particular, are at the heart of financial cycles and can greatly amplify real business cycles (Adrian & Shin, 2010). Since then, the incorporation of the banking sector in the general equilibrium setting has become quite a standard feature of NK models. Typically, the analysis concentrates on exogenous shocks, amplified in the financial sector. Traditional DSGE models usually emphasize the demand side of credit and relate shock amplification to exogenous fluctuations in the price of collateral or net worth of the borrower, based on the models of Kiyotaki and Moore (1997) and Bernanke, Gertler, and Gilchrist (1999). A number of papers study the role of bank capital in amplifying macroeconomic shocks (see, e.g. Meh & Moran, 2010; van den Heuvel, 2008). Another strand of literature (Cúrdia & Woodford, 2009; Gerali, Neri, Sessa, & Signoretti, 2010; Goodfriend & McCallum, 2007) is more concerned with the supply side of credit, whereby time-varying lending margins are determined by the degree of competition in the banking sector, risk perceptions, bank leverage, capital buffers, rate stickiness, etc. Some models (Clerc et al., 2015) also link banks' excessive risk taking and overleverage to limited bank liability and deposit insurance. More generally, much of this literature maintains that the role of banks in amplifying the financial cycles boils down to procyclical financial constraints, information asymmetries and other market frictions. The main problem with this class of models is that they are trying to explain the workings of the banking system and intrinsically monetary phenomena by resorting to an effectively real analysis (Borio, 2012).

Assumption of credit risks is inherent to banking intermediation, and materialization of these risks can precipitate bank defaults and is closely linked to the occurrence of major financial crises (Goodhart, Tsomocos, & Shubik, 2013). Most DSGE models, which include the banking sector and credit risks, assume exogenous defaults (see, e.g. Iacoviello, 2005, 2015, for a straightforward incorporation of exogenous default risks). Moreover, credit risk is typically assumed to be idiosyncratic and thus fully diversifiable by state-contingent contracts (as in Bernanke et al., 1999), which does not square with the fact that bank lending involves an inherent systemic, or non-diversifiable, risk component. A realistic treatment of endogenous defaults, or endogenous systemic crises, would require a comprehensive feedback mechanism, whereby the systemic risk would depend on the phase of the financial cycle and on the banking activity itself. Several recent studies, most notably Beneš, Kumhof, and Laxton (2014a), Jakab and Kumhof (2015), Boissay, Collard, and Smets (2016), and Clancy and Merola (2017), incorporate non-diversifiable risks and endogenous defaults.

Critics point out, however that the NK macroeconomic analysis may be in principle incapable of explaining boom-and-bust cycles and financial crises because they seem to be inherently disequilibrium phenomena, and the boom may not just precede but actually cause the bust (Borio, 2011). Indeed, trying to explain financial cycles and the occurrence of immensely costly financial crises by relying on the fundamental premise that economies trace out equilibrium outcomes based on agents' optimizing behaviour subject to (exogenous) shocks is at least to some extent a self-contradictory proposition. Moreover, empirical evidence suggests that episodes of financial instability are likely to be the result of credit booms gone wrong due to failures of operation or regulation of the financial system (Schularick & Taylor, 2012). This is hardly in line with the notion of self-correcting and optimizing economic and financial systems deeply ingrained in the NK paradigm.

## 2.2. Role of banks in creation of money and new purchasing power

Banks' ability to create new purchasing power is known as the 'credit first' or 'financing through money creation' (FMC) view on banking intermediation.[1] The effective ignorance of the fact that banks do not merely redistribute resources but rather create money and new (nominal) purchasing power is one of the major flaws of the contemporary banking theory[2] and the mainstream macroeconomic paradigm (Borio, 2012). Potential implications of the neglect of actual institutional features that enable banks to create purchasing power could be immense and could turn a lot of the contemporary macroeconomic theory on its head. Some authors even go so far as to conclude that because of this ignorance 'there is at present no theoretical analysis of banking worthy of the name' (Goodhart et al., 2013).

To understand the special role of banks in the process of financing through money creation, first consider the mechanics of credit issuance. It is an accounting fact that banks normally create credit by expanding their balance sheets, i.e. they add new loans on the asset side of their balance sheets and simultaneously create matching liabilities (deposits) issued to the same borrower (see, e.g. Beneš et al., 2014a; Disyatat, 2011; Werner, 2014). Simply put, banks have the extraordinary right to credit their customers' accounts at will and thereby create money *ex nihilo*, without the necessity to accumulate loanable resources beforehand (Jakab & Kumhof, 2015; King, 2012; Turner, 2013). This is by

no means a new breakthrough in thinking about banking intermediation, as such interpretation of principles of credit and money creation dates back at least to Wicksell (1906). Moreover, the 'credit first' view had become a dominant paradigm by the 1930s (Jakab & Kumhof, 2015). However, in the 1950s fundamental differences between banks and other financial intermediaries became blurred in economic theorizing of the time, which led to the return of the simplistic 'deposits first' view. Together with this view, another popular misconception, namely the notion of money multiplier, gained prominence among economists and monetary policymakers. The money multiplier concept implies that monetary policy is implemented by changes in reserves supplied by the central bank, which, through the required reserve ratio, mechanically affects the stock of bank deposits and this in turn determines banks' ability to supply credit. As noted by Disyatat (2008, 2011) and others, this way of reasoning is flawed because the causality runs in exactly the opposite way (loans create deposits, not vice versa), and also, contemporary central banks effectively ensure elastic supply of reserves demanded by the banking system. The 'money multiplier' view was further discredited when the expansion of monetary base by major central banks in reaction to the recent global financial crisis did not automatically lead to a large scale expansion of broad money and bank lending, contrary to the expectations of numerous proponents of the 'money multiplier' view (Goodhart et al., 2013). In any case, misconceptions about money creation and the ill-perceived relationship between money and bank credit led to a largely ad hoc and incoherent treatment of money in the mainstream general equilibrium macroeconomic analysis. What we are witnessing now is a growing number of researchers from leading policy institutions such as the International Monetary Fund (IMF), the Bank of England (BoE) and the Bank for International Settlements (BIS) calling for a more realistic treatment of institutional features of money and bank credit (see e.g. Beneš et al., 2014a and, especially, McLeay et al., 2014) and for development of genuinely monetary macroeconomic models (Borio, 2012).

So what makes deposit-taking financial institutions special and distinguishes them from other financial intermediaries? It is the ability to finance their loan and investment portfolios by issuing liabilities that serve as a generally accepted means of payment, i.e. money (Hart & Zingales, 2011; OECD, 2017). Furthermore, bank deposits do not represent real savings (i.e. postponed consumption or unconsumed real resources) because they can be immediately, or on short notice, used to buy goods and services and, notably, being monetary in nature they do not get used up in the process. In other words, as deposits are used for settlements, this typically does not lead to a funding shortage for the banking system as a whole. And in the case of individual banks' liquidity shortages, they can be effectively attenuated by resorting to interbank loans or by borrowing reserves from the central bank. Thus, all of this implies that by writing credit contracts banks create new deposits, i.e. new money or purchasing power that previously did not exist, whereas other forms of financial intermediation transfer existing means of payment from creditors to borrowers (Spahn, 2014). Seen from a different vantage point, money-like qualities of bank liabilities enable 'double spending' of these funds (because in general changes in ownership of deposit claims do not undermine financing of the banking system as a whole) unlike other financial intermediation, which relies on financing with less liquid liabilities and equity.

In the context of the prevailing ILF paradigm, whereby financial flows in the economy are treated with insufficient rigour, there is a tendency to conflate the notions of saving

and financing. For example, many economists regard the 'global savings glut' (the term coined by Bernanke, 2005), and in particular excess saving in emerging economies, as one of the crucial macroeconomic factors behind the last decade's boom-and-bust cycle in the US and the ensuing global financial crisis. Borio and Disyatat (2011) strongly criticize the idea and show that saving rates and current account imbalances tell very little about the actual financing structure in a particular economy, its cross-border financial flows and its reliance on foreign funding. Notably, they conjecture that it was the 'excess elasticity' of the international financial system rather than 'excess foreign saving' that contributed most to the boom-and-bust cycle. Here elasticity means the above discussed ability of the financial system to expand without strict dependence on real factors (such as real saving), and by excess elasticity it's meant that there was a lack of sufficiently strong anchors to prevent unsustainable booms.

To better understand the actual role played by bank lending in the macroeconomic context, it is useful to consider various sources of financing in the context of macroeconomic accounting of economic and financial flows (see Lequiller & Blades, 2014; OECD, 2017). Suppose the corporate sector (a representative firm) wants to invest in the manufacturing equipment and the only option for external financing is borrowing from the household sector (a representative household), which has no pre-accumulated financial wealth. In this case the household's consumption vs. saving decision is critical for the firm's ability to acquire capital because household's saving directly enables financing of firm's capital acquisition. In financial accounts this financing transaction would be reflected as an increase in the household's net financial wealth (because of the credit claim on the firm) and a commensurate decrease in the firm's net financial wealth (because of the incurred debt liability to the household). This illustrates the basic principle of sectoral nonmonetary financing: an institutional sector can finance its excess expenditure (i.e. spending in excess of its income) by running down its net financial assets. In a more realistic financial setting, the firm would have a much wider set of financing options: it could acquire financing from various institutional sectors, including the rest of the world, and it could use various financial instruments. For example, the firm could finance its investment by issuing equity or bonds, by selling its holdings of financial assets such as government bonds, by running down its money holdings (cash balances or bank deposits) or by borrowing from the bank. Importantly, the financing transaction could take place, disconnected from the current saving behaviour of the provider of financing (as is also noted by Borio & Disyatat, 2011), but rather out of the previously accumulated financial wealth. In that case, the provider of the nonmonetary financing would experience a change in its financial asset composition, for instance, a decline in its cash holdings and a commensurate increase in credit claims on the firm, but no expansion of its financial balance sheet. In contrast, a commercial bank, as a provider of monetary financing, expands its balance sheet as it creates both loans and deposits (see IMF, 2014). Such bank credit transaction creates a new deposit as the instrument to finance the firm's investment expenditure, without relying on any agent's conscious decision to save (i.e. to constrain the current expenditure) at the initial moment. Once the firm settles for the purchase of manufacturing equipment, the seller of investment goods earns nominal income and accumulates deposits as a result of the transaction, ensuring that the bank balance sheet remains balanced. At this level of abstraction and without a concrete model, it is difficult to pinpoint the actual 'saver' – changes in

real saving are ultimately determined by credit-induced price, income and expenditure changes.

More generally, bank credit creates new purchasing power, which directly supports an increase in domestic demand and this in turn translates into (nominal) income rises of either domestic or foreign residents (see Ramanauskas, Matkėnaitė, & Rutkauskas, 2016a, 2016b). This stands in contrast to financial intermediation of current savings, as its immediate impact on domestic demand should effectively be zero (saving can inter-preted as the 'hole' in aggregate consumption spending exactly offset by investment expenditure , see Borio, 2012). Credit-fuelled domestic demand stimulus should induce increases in both economic activity and prices, with the relative strength of the impact depending on the phase of the financial cycle, utilization rates of production resources, degree of firm competitiveness and their pricing power, etc. In modelling terms, the acknowledgement of banks' ability to provide financing without directly and solely relying on aggregate savings in the economy takes a lot of emphasis off households' saving decisions and puts that on the financial sector. In the real world, it seems that it is exactly this demand-stimulating effect of bank credit and the elasticity of financial systems that might be responsible for rampant boom-and-bust cycles, widespread over-reliance of advanced economies on continuous debt accumulation and the resultant chronic over-indebtedness (see BIS, 2016; Jordà, Schularick, & Taylor, 2017).

In the macroeconomic context, the elasticity of the financial system or the degree of self-financing of bank credit expansion should primarily depend on the flexibility of the supply side of the economy: if firms are unable to raise prices or increase production in response to credit-fuelled demand, imports would rise more strongly, constraining growth of domestic nominal incomes, as well as leading to financial outflows from the economy and exposing banks to financing gaps because of lost deposits. From the credit supply perspective, rather than being limited by pre-accumulated real resources, credit issuance is more likely to be limited by bank's profitability prospects, solvency requirements and capital constraints, the stance of macroprudential policy, willingness to take out loans by borrowers, collateral valuations, etc. (OECD, 2017). So, in order to study the limits to credit issuance and the macroeconomic impact of credit over the medium to long term, it does not suffice to understand correctly the basic principles of credit and money creation (such as the precedence of credit over deposits at the micro-economic level at the first instance of credit creation) – one still has to meaningfully incor-porate bank credit in a macroeconomic modelling setup.

## 2.3. Inclusion of banks in macroeconomic analysis

How to properly include banks in a macroeconomic model is still an unresolved issue. A very small strand of the DSGE literature, in which the 'credit first' view is explicitly sup-ported, includes several conceptually related models developed by the IMF (Beneš & Kumhof, 2012; Beneš et al., 2014a; Bene, Kumhof, & Laxton, 2014b) and the BoE (Jakab & Kumhof, 2015). Beneš et al. (2014a), for example, emphasize the importance of allowing credit to depend on demand for financing rather than the act of saving. According to them, the amount of aggregate saving cannot be a factor that directly limits the size of bank balance sheets. Beneš and Kumhof (2012) argue that saving is a slow-moving state variable, whereas bank assets (loans) and liabilities (money) can be created and

destroyed at a moment's notice. To generate this feature, they allow financially constrained households in their model to borrow from banks and receive those loans in the form of a newly created deposit. They also point to the ability to trade fixed and financial assets between financially constrained and unconstrained agents as another feature, which is important for proper modelling of banking intermediation. In a related paper, Jakab and Kumhof (2015) provide a list of ingredients that, in their view, make their model an FMC model: banks do not intermediate pre-existing loanable funds in the form of goods but rather create new deposits (money) through lending; household demand for bank deposits is modelled as a technology that saves transaction costs; banks have their own balance sheet and net worth; banks as lenders are exposed to non-diversifiable credit risk (rather than price risk), which is partly due to non-contingent lending interest rates; bank capital is subject to Basel type regulation and acquiring bank capital from equity markets is subject to market imperfections. Comparing FMC models with otherwise analogous ILF models, Jakab and Kumhof (2015) show that, in line with stylized facts, models with the FMC feature generate larger and faster changes in bank balance sheets, procyclical bank leverage and smaller dependence of adjustment processes on changes in lending rates. The fundamental difference between the results is associated with relatively gradual change in financing through accumulation of savings in ILF models as opposed to instantaneous creation of purchasing power through the expansion of bank balance sheets in FMC models.

In the current paper we argue, however, that conditions for the basic representation of financing through money creation in a DSGE setting are probably much less stringent than implied by Jakab and Kumhof (2015). Our DSGE model is comprised of almost entirely standard building blocks and yet is capable of generating largely self-financing credit extension at the will of the banker. In our view, the modelling features that enable a meaningful analysis of bank credit and that are crucial for capturing financing through money creation are as follows.

First and foremost, the model should represent an internally consistent closed dynamic system. Though the DSGE framework can be criticized, among other things, for its unrealistic treatment of behavioural aspects of the economy, such as the imposed rationality of agents, yet the main virtue of the DSGE framework for our purposes is that it allows to model the economy as a dynamic, internally consistent system, with elaborate microeconomic and macroeconomic constraints. Like many other DSGE models, our model incorporates crucial institutional features of the economy, such as corporate balance sheets and profit and loss accounts, institutional features of financial intermediaries (e.g. the dual role of deposits as both saving and settlement instrument), household budget constraints, income and production aggregation constraints, international financial constraints, etc. Our model is fully in line with integrated economic and financial accounts and thus retain the so-called stock-flow consistency – a much sought-after modelling feature, which, according to the proponents of stock-flow consistent modelling, is at the heart of correct modelling of credit and money creation (Godley & Lavoie, 2012). The key point here is that the process of money creation by banks is an institutional rather than behavioural feature – it is the institutional setting that enables banks to create purchasing power, and banks' motives, incentives or even awareness of the fact are of secondary importance. Therefore a correct representation of institutional features is crucial and the basic DSGE framework can do a very good job in this regard.

This brings us to the next important modelling feature, namely, the incorporation of a representative bank with its own balance sheet, dual-purpose deposits and the autonomous decision making power. For convenience and clearer exposition purposes, physical cash can be safely excluded from the model so that money takes the form of banks deposits and is thus determined endogenously in the model. As the bank issues new loans, it simultaneously creates new deposits, and a large fraction of them remain in the banking system once economic transactions supported by bank credit are settled. Thus, the saver makes the decision how to redistribute the existing purchasing power by choosing between consumption and saving (e.g. in the form of deposits). The bank simultaneously makes a decision how much new (nominal) purchasing power to create by issuing new loans and thereby creating new deposits. The interaction of these two decision makers in principle determines the amount of total financing in the model economy. Jakab and Kumhof (2015) point out that bank deposits should not be predetermined to enable a correct modelling of the money creation processes. This is of course true but it should be noted that typically it is fully recognized in standard modelling practice, as in most standard models loans and deposits are simultaneously and endogenously determined in general equilibrium.

A meaningful analysis of banks and credit also requires the assumption of some sort of heterogeneity and agents' imperfect knowledge of the economic environment. In our model we attain heterogeneity taking a quite standard approach, namely, by making the representative household a saver and holder of bank deposits and making the firm sector take loans from banks. In our model there is no omniscient central planner and economic agents do not fully internalize various endogenous variables. For example, much like in the real world, a firm in our model may not clearly distinguish a credit-fuelled increase in demand for its products from a consumer preference shock or a bank may not recognize the impact of its decision to extend a new loan on inflation.

Finally, but very importantly, the macroeconomic role of banks will remain concealed if the model does not include prices, as well as a realistic price identification mechanism, and if, according to Borio (2011), 'real' models are disguised as 'monetary' ones. Banks cannot create real resources, thus in real settings their role effectively reduces to the intermediation of loanable funds. In contrast, in settings with endogenously determined prices (and endogenously created money) banks do create nominal means of payment thereby shifting the balance of purchasing power towards the borrower, changing the supply and demand balance in product and labour markets, altering inflationary outlook and expectations and, generally, producing real and nominal effects on the economy. Prices are ultimately determined in the general equilibrium with the help of an identifying condition. Notably, the standard Taylor rule would imply automatic tightening of the monetary policy in response to (credit-induced) inflationary pressures, thereby impeding the process of financing through money creation. Since the current paper's focus is on a small open economy taking part in a monetary union, in which the centralized monetary policy is largely unresponsive to developments in the economy of interest, we replace the Taylor rule with a simple external competitiveness condition. Its rationale is simple – banks may create purchasing power in the domestic economy but as inflationary pressures mount, the economy gradually loses external competitiveness and net financial outflows intensify, effectively including the limit on financing through money creation.

## 3. Model setup

In this section we will briefly describe our stylized model of a small open economy with the functional banking sector.[3] Some features of the model, such as the foreign ownership of banks or the absence of domestic monetary policy rules, reflect the specificities of the Lithuanian economy but the main insights are quite general. The model economy comprises three sectors – households, firms and banks – and engages in economic and financial transactions with the rest of the world (see Figure 1). The household sector is completely standard. It consists of an infinitely-lived representative household that values real consumption and leisure and provides labour services to firms (which are owned by the household sector). The household earns wages and is entitled to the dividend stream of firms. The household does not borrow and is a net saver – all its savings are deposited in a bank, earning a market-determined interest income.

The firm sector is divided into competitive final goods producers, or a primitive 'assembly and packaging' industry, and monopolistically competitive intermediate goods producers, which are central to the firm sector. This distinction between final and intermediate goods producers is rather artificial and it is just a standard modelling device to ensure that the productive sector as a whole retains some pricing power, governed by demand elasticity parameters. The final good is homogeneous and can be either consumed or invested. Intermediate goods producers employ labour and capital. They are the owners of physical capital and finance its accumulation from retained earnings and bank loans. Since producers of intermediate goods are monopolistically competitive, they earn non-zero profits,
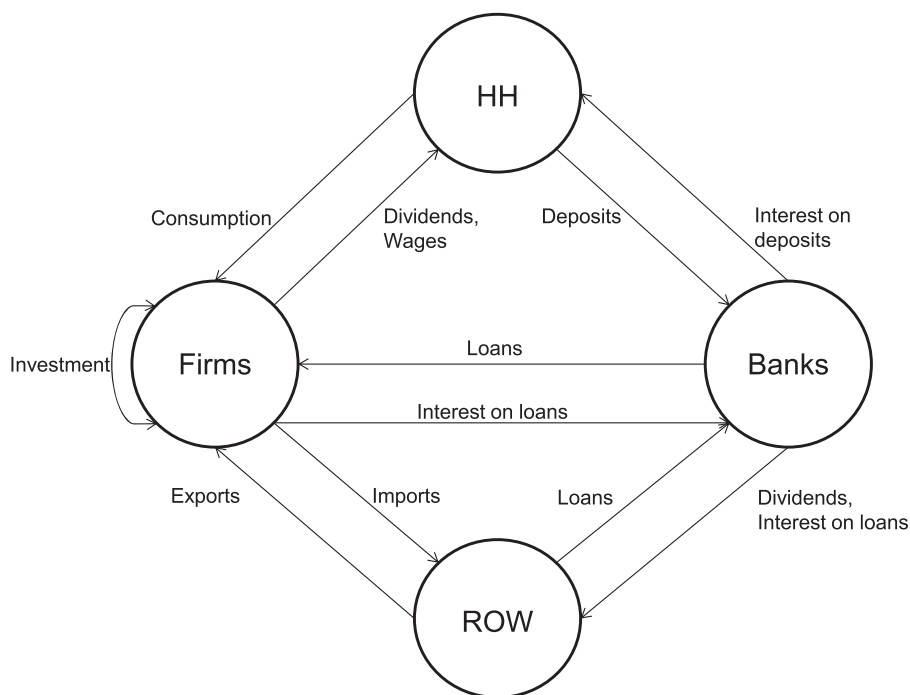


**Figure 1.** Schematic view of the model.

decide on the dividend policy and are set to maximize discounted dividend streams, subject to investment and price adjustment costs. The firm sector is a net borrower and takes loans from the bank. Notably, intermediate firms do not have access to bank deposits but they adjust their outstanding loan balances instead.[4]

A competitive representative bank takes deposits from the household sector, extends loans to firms and intermediates the domestic economy's borrowing from (or lending to) the rest of the world. The bank is subject to capital requirements and wants to hold a capital buffer above the minimum requirement. The banker wants to maximize the utility derived from the stream of bank dividend payouts, which are consumed abroad. Importantly, bank's deposits are the instrument of both settlement and saving in the economy. Accounting relationships in the general equilibrium setting ensure that an increase in bank loans results in a contemporaneous rise in deposits accompanied by stronger domestic demand and inflationary pressures.

In the remainder of this section we outline the model's building blocks in more technical detail.

### 3.1. Households

The representative household obtains utility from consumption and disutility from labour. The instantaneous utility function is given by

$$U(C_t, L_t) = U_t = \log C_t - \sigma_L \frac{L_t^2}{2},$$ (1)

where $C_t$ is consumption and $L_t$ is labour. The household's flow budget constraint states that the household's disposable income, comprised of wage income, dividends and interest income, can be spent on consumption or saved in the form of bank deposits. Formally it is

$$W_t L_t + Div_t + r_{D_{t-1}} D_{H_{t-1}} = P_t C_t + \Delta D_{H_t},$$ (2)

where $W_t$ is the nominal wage, $Div_t$ denotes nominal dividends received from firms, $P_t$ is the price level, $D_{H_t}$ is the end-of-period stock of nominal deposits and $r_{D_{t-1}}$ is the nominal interest rate on deposits held in period $t{-}1$. Note the timing convention whereby the deposit is determined at the end of the period, as a result of household's saving vs. consumption choice, and is held for one period into the future. So, the deposit contracted in period $t{-}1$ will yield an *a priori* agreed interest payment in period $t$ and this will contribute to the household's disposable income of period $t$. Also note that the budget constraint is expressed in nominal terms. We do not apply a special notation to distinguish between real and nominal variables, therefore to avoid possible confusion we will explicitly point out which variables are which in the text.

Household's discounted lifetime utility function is

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \nu_t(U(C_t, L_t)),$$ (3)

where $\beta$ is the household's impatience parameter and $\nu_t$ is a shock to intertemporal preferences that is equal to unity in the steady state. The household maximizes the utility by choosing optimal levels of consumption, labour and deposits. $\lambda_{H,t}$ being the Lagrangian

multiplier, associated with constraint (2), the labour supply and Euler equations are

$$\sigma_L L_t = \frac{W_t}{P_t C_t},$$ (4)

$$\beta \mathbb{E}_t \left[ \frac{\nu_{t+1}}{\nu_t} \frac{(1 + r_{D_t}) P_t}{P_{t+1} C_{t+1}} \right] = \frac{1}{C_t}.$$ (5)

Equation (4) states that, all else being equal, the household supplies more labour as real wages rise. Equation (5) is a standard Euler equation. An unexpected increase in $\nu_{t+1}$ over $\nu_t$ will be interpreted as a positive willingness to save shock (see Section 5.1.2).

## 3.2. Firms

The firm sector is comprised of competitive producers of final goods and monopolistically competitive intermediate good producers. The homogeneous final goods are produced from intermediate goods and are suitable for both consumption and investment and can be used domestically or exported.

### 3.2.1. Production of final goods

A representative perfectly competitive producer of final goods relies on the Dixit–Stiglitz production technology to produce the final goods from the continuum of different intermediate goods:

$$Y_t = \left( \int_0^1 y_{j,t}^{(\varepsilon-1)/\varepsilon} \, \mathrm{d}j \right)^{\varepsilon/(\varepsilon-1)},$$

where $Y_t$ is the quantity of the final good produced, $y_{j,t}$ is the amount intermediate good $j$ used in the production process and $\varepsilon$ is a nonnegative parameter governing elasticity of demand for intermediate goods. The firm decides on the quantities of intermediate goods to maximize its profits.

$$\max_{y_{j,t}} \left[ P_t \left( \int_0^1 y_{j,t}^{(\varepsilon-1)/\varepsilon} \, \mathrm{d}j \right)^{\varepsilon/(\varepsilon-1)} - \int_0^1 p_{j,t} y_{j,t} \, \mathrm{d}j \right],$$

which results in the following demand curve for the $j$th intermediate input:

$$y_{j,t} = Y_t \left( \frac{p_{j,t}}{P_t} \right)^{-\varepsilon}.$$ (6)

Given that $\varepsilon$ is nonnegative, this equation essentially ensures the downward sloping demand curve for individual producers of intermediate goods.

### 3.2.2. Intermediate goods producers

Modelling intermediate goods production is considerably more elaborate. Producers of intermediate goods act in a monopolistic competition market, they employ capital and labour to produce their products, with the aim of maximizing dividend pay-outs, subject to various constraints. Firm $j$ produces $j$th intermediate good using the standard

Cobb–Douglas technology:

$$y_{j,t} = A_t K_{j,t-1}^\alpha L_{j,t}^{1-\alpha}, \tag{7}$$

where $A_t$ is the Hicks-neutral total factor productivity that is common to all firms. $K_{j,t-1}$ and $L_{j,t}$ are, respectively, physical capital and labour employed by firm $j$. Note again the timing and accounting conventions whereby $K_{j,t}$ denotes the capital stock at the end of period $t$, and only fully installed capital, i.e. last period's capital $K_{j,t-1}$, can be used for production of period $t$ output. Likewise, capital starts to depreciate once it is employed in the production process. The capital motion equation is given by

$$K_{j,t} = K_{j,t-1}(1 - \delta) + I_{j,t}, \tag{8}$$

where $I_{j,t}$ is firm $j$'s real investment and $\delta$ is a constant depreciation rate. So, the capital stock of period $t-1$ is put in production and depreciates in period $t$, whereas period $t$ investment expenditure contributes to contemporaneous increase in capital stock with an effect on production in period $t+1$.

In addition to physical constraint of capital motion, firms must obey the following accounting balance-sheet constraint:

$$P_t K_{j,t} = L_{F_{j,t}} + \Pi_{j,t}, \tag{9}$$

which states that firm's assets, i.e. physical capital in nominal terms, must be financed either externally, with nominal bank loans $L_{F_{jt}}$, or internally, with firm equity $\Pi_{jt}$. Firm equity is simply retained earnings – last period's equity plus current period's profits $\pi_{jt}$ minus current dividend pay-outs $Div_{jt}$:

$$\Pi_{j,t} = \Pi_{j,t-1} + \pi_{j,t} - Div_{j,t}. \tag{10}$$

Our simple firm has its balance sheet, and we can also formulate its profit/loss (P&L) account in accordance with basic business accounting principles:

$$\pi_{j,t} = p_{j,t} y_{j,t} - W_t L_{j,t} - P_t \delta K_{j,t-1} - r_{L_{t-1}} L_{F_{j,t-1}} - \Omega_{j,t}^I - \Omega_{j,t}^P + K_{j,t-1} \Delta P_t. \tag{11}$$

This equation essentially states that firm $j$'s nominal profit is the difference between firm's nominal sales and all expenses. The firm incurs the wage bill, capital depreciation expenses, and financial expenses in the form of previously agreed interest payments $r_{L_{t-1}}$ on outstanding bank loans. We also impose on the firm investment adjustment costs $\Omega_{j,t}^I$ and price adjustment costs $\Omega_{j,t}^P$. This is needed in order to technically smooth out model's responses but these expenses – or output losses related to installation of new capital or adjusting prices – also naturally show up in the P&L account. The last term in firm's P&L account is the nominal capital gains. It is a logical inclusion from the accounting perspective but, in modelling terms, it is also necessary in order to ensure that the firm's balance sheet (Equation (9)) remains balanced as prices change. Lastly,

we specify price adjustment costs:

$$\Omega_{j,t}^{P} = \frac{\psi_P}{2}\left(\frac{p_{j,t}}{p_{j,t-1}} - 1\right)^2 P_t y_{j,t},$$

(12)

$$\Omega_{j,t}^{I} = \frac{\psi_I}{2}\left(\frac{I_{j,t}}{I_{j,t-1}} - 1\right)^2 P_t I_{j,t}.$$

(13)

$\psi_P$ and $\psi_I$ are the parameters regulating the costliness of respective adjustment processes.

In our model, we take account of the financial structure of the firm sector and this ensures that the institutional environment is rich enough to enable us to track economic and financial flows between sectors and ensure the model's internal consistency at the macro level. On the other hand, the profit function in Equation (11) may not be immediately recognizable in the context of DSGE modelling. Moreover, the nominal capital gains term in the profit function has little to do with real shareholder value. Therefore we postulate that firms are more concerned about the discounted dividend pay-outs as their optimization objective. One can easily derive the expression for dividends from the profits equation (11) by substituting in constraints (8)–(10) and applying some algebraic manipulation:

$$Div_{j,t} = p_{j,t}y_{j,t} - W_t L_{j,t} - P_t I_{j,t} + L_{F_{j,t}} - (1 + r_{L_{t-1}})L_{F_{j,t-1}} - \Omega_{j,t}^{I} - \Omega_{j,t}^{P}.$$

(14)

We thus have obtained the expression for dividend pay-outs, which is not necessary for the model solution *per se*, but it more closely resembles the textbook formulation of firm's optimization problem. Comparing to the profit formulation in Equation (11), we can immediately see that the dividend pay-out is a cash-flow concept, as one has to exclude non-cash items such as depreciation expenses or unrealized capital gains but add such cash flows as borrowing from banks. The important insight from this simple analysis is that DSGE models can incorporate a reasonably high level of institutional detail and the gap between business accounting principles and the DSGE accounting framework is not necessarily very significant.

Before putting together the firm's optimization problem formally, we introduce one more financial constraint. With the aim of being able to calibrate more precisely the level of firm indebtedness, we assume that firms face the so-called loan-to-value (LTV) constraint, which implies that there can be only collateralized lending to firms and it may not exceed $\eta_K$ fraction of the value of firm capital pledged as collateral:

$$L_{F_{j,t}} \leq \eta_K P_t K_{j,t}.$$

(15)

Firm $j$ is assumed to maximize the expected discounted real dividend stream with respect to $Div_{j,t}, \Pi_{j,t}, L_{F_{j,t}}, I_{j,t}, L_{j,t}, p_{j,t}, K_{j,t}$, subject to constraints (8)–(10) and (15). We use $\beta_F$ as the firm's discount factor, representing the impatience of the firm's management. Assumption that $\beta_F \leq (1 + r_L)^{-1}$ ensures that the management is impatient enough so that the LTV constraint is binding in the neighbourhood of the steady state.

Assuming firm symmetry, which allows us to drop subscripts $j$, we get the following first order conditions of firm's optimization problem:

$$\lambda_{2,t} = -\frac{1}{P_t} + \beta_F \mathbb{E}_t \left[ \frac{1}{P_{t+1}} \right], \tag{16}$$

$$\lambda_{3,t} = -\frac{1}{P_t} + \beta_F (1 + r_{L,t}) \mathbb{E}_t \left[ \frac{1}{P_{t+1}} \right], \tag{17}$$

$$\lambda_{4,t} = -\frac{1}{P_t} \frac{\partial \Omega_t^I}{\partial I_t} - \beta_F \mathbb{E}_t \left[ \frac{1}{P_{t+1}} \frac{\partial \Omega_{t+1}^I}{\partial I_t} \right], \quad \lambda_{5,t} = \frac{L_t}{(1-\alpha)P_t Y_t} \left( W_t + \frac{\partial \Omega_t^P}{\partial L_t} \right) - 1, \tag{18}$$

$$Y_t (1 + \varepsilon \lambda_{5,t}) = \frac{\partial \Omega_t^P}{\partial P_t} + \beta_F \mathbb{E}_t \left[ \frac{P_t}{P_{t+1}} \frac{\partial \Omega_{t+1}^P}{\partial P_t} \right], \tag{19}$$

$$(\eta_K P_t \lambda_{3,t} - P_t \lambda_{2,t} - \lambda_{4,t}) = \beta_F \mathbb{E}_t \left[ \alpha \frac{Y_{t+1}}{K_t} (1 + \lambda_{5,t+1}) + 1 - \delta - \frac{P_t}{P_{t+1}} \right.$$
$$\left. - \lambda_{4,t+1}(1-\delta) - \frac{1}{P_{t+1}} \frac{\partial \Omega_{t+1}^P}{\partial K_t} \right]. \tag{20}$$

$\lambda_{i,t}$, $i = \overline{1,5}$, denote the Lagrange multipliers associated with constraints (10), (9), (15), (8) and (6), respectively. Expressions for partial derivatives of adjustment costs are provided in the equation list in Appendix 4.

Hereafter we refer to intermediate producers or the production sector as a whole simply as firms. Note that the final good producers are simply used as a modelling device to ensure that the productive sector as a whole retains some pricing power.

### 3.3. Banks

The financial sector in the model consists of a representative competitive foreign-owned bank. The bank has a stylized balance sheet comprised of just one asset (loans to firms), liabilities in the form of deposits and foreign debt ($F_t$), and equity ($E_t$):

$$L_{F_t} = D_{H_t} + F_t + E_t. \tag{21}$$

Just like in the intermediate firms' case, the bank's balance sheet is expressed in nominal terms. Bank equity is defined in a similar way as firms' equity:

$$E_t = E_{t-1} - DivB_t + \pi_t^B, \tag{22}$$

where $DivB_t$ denotes endogenous bank dividends and $\pi_t^B$ is bank profits. Assuming that bank dividends are non-negative, the bank may accumulate equity only from retained earnings; thus, external equity financing is assumed away for simplicity.

The model in its present form does not incorporate credit risk. For this reason, the model does not provide an explanation as to why a significant share of bank financing comes in the form of equity financing. Furthermore, in the competitive equilibrium, profits, and thereby the value of equity, would naturally go to zero. In order to institute positive bank equity we exogenously impose a Basel-style minimum capital requirement

and also assume a financial cost inversely related to the capital buffer in excess of the minimum requirement. So, the bank earns interest income on loans and pays interest on deposits and foreign borrowing, as well as incurs financial costs related to the capital buffer, which results in the following bank profit function:

$$\pi_t^B = r_{L_{t-1}} L_{F_{t-1}} - r_{D_{t-1}} D_{H_{t-1}} - r_{F_{t-1}} F_{t-1} - \Omega_{t-1}^B, \tag{23}$$

where $r_{L_t}$, $r_{D_t}$ and $r_{F_t}$ denote, respectively, nominal interest rates on loans, deposits and banks' foreign debt and $\Omega_{t-1}^B$ is the financial cost associated with thin capital buffer. Note that the specification of the bank profit function implies that today's profits are determined by yesterday's decisions. This reflects the inherently intertemporal nature of finance but in the absence of credit risk the timing choice does not materially change the optimizing and forward-looking banker's problem. Notably, other authors apply varying interest timing conventions, depending on their analytical objectives (e.g. Gerali et al., 2010; Iacoviello, 2015).

To specify the financial cost $\Omega_t^B$ we employ a logarithmic function as in Furfine (2001):

$$\Omega_t^B = -\gamma \log \left( \frac{E_t}{\omega L_{F_t}} - \mu_t \right) L_{F_t}, \tag{24}$$

where $\mu_t$ is the minimum capital requirement, $\omega$ is a risk weight and $\gamma$ is the parameter reflecting the financial pain associated with the thin capital buffer. The logarithmic cost function is well defined and yields a negative value when the argument, i.e. capital buffer, is between zero and unity, therefore we assume that $\gamma$ is a nonnegative parameter. It should be said that this formulation is a simplification suitable for the case with no credit risk and actual bank failures because it simply does not allow bank capital to go below the required minimum as that would result in infinitely large financial cost to the bank.

We also specify the upward sloping foreign financing supply function, similar to Schmitt-Grohé and Uribe (2003), Vītola and Ajevskis (2011), and Lozej, Onorante, and Rannenberg (2017). It states that the interest rate on banks' foreign debt positively depends on the nominal foreign debt-to-GDP ratio:

$$r_{F_t} = r_t^* \left( \phi_0 + \phi_1 \frac{F_t}{P_t Y_t} \right), \tag{25}$$

where $r_t^*$ is the risk-free interest rate on borrowing in foreign financial markets and $\phi_0$ and $\phi_1$ are non-negative parameters. One can interpret $r_t^*$ as the interbank rate that can be directly affected by exogenous monetary policy shocks.

It is assumed that banks are owned by an impatient foreign household who receives dividends and spends them on consumption abroad. The flow budget constraint is $P_t^* C_t^* = DivB_t$, where $P_t^*$ is the foreign price level and $C_t^*$ is foreign consumption of the banker. The instantaneous utility function is $\log C_t^*$. Given the banker's rate of time preference $\beta_B$, maximization of discounted lifetime utility with respect to $DivB_t$, $L_{F_t}$, $F_t$, and $E_t$,

subject to constraints (21)–(23), leads to the following first order conditions:

$$\frac{1}{DivB_t} = \beta_B \mathbb{E}_t \left[ \frac{1}{DivB_{t+1}} \right] \left( 1 + r_{D_t} + \gamma \frac{L_{F_t}}{E_t - \mu_t \omega L_{F_t}} \right),$$ (26)

$$r_{L_t} - r_{D_t} = \gamma \left( \frac{E_t}{E_t - \mu_t \omega_t L_{F_t}} - \log \left( \frac{E_t}{\omega L_{F_t}} - \mu_t \right) \right),$$ (27)

$$F_t = P_t Y_t \frac{r_{D_t} - \phi_0 r_t^*}{2\phi_1 r_t^*}.$$ (28)

There is a close analogy between the banker's Euler equation (26) and the household's Euler equation (5). The banker equates the marginal rate of substitution between dividends today and tomorrow to the relative price of dividend pay-outs. Thus, withholding dividend pay-outs for one period spares the bank from paying alternative financing cost $r_{D_t}$ to depositors and also reduces the marginal financial cost associated with a thin capital buffer. Notably, the larger the capital buffer gets, the more inclined the banker becomes to pay out the dividends, all else being constant.

Equation (27) establishes that bank's capital buffers are increasing along with an increasing interest rate margin. Equation (28) governs demand for foreign debt. Foreign debt is positive when the difference between deposit rates and the risk-free foreign rate is sufficiently large, in other words, when foreign borrowing is relatively cheap. All else being equal, the lower risk-free foreign rate naturally implies stronger demand for bank's borrowing from abroad.

### 3.4. Closing equations

Adding the household's budget constraint together with intermediate producers' and bank's balance-sheet constraints, we obtain the following aggregate resource constraint and the balance-of-payments identity:

$$P_t Y_t = P_t C_t + P_t I_t + \Omega_t^I + \Omega_t^P + \Omega_t^B + P_t NX_t,$$ (29)

$$P_t NX_t - DivB_t - r_{F_{t-1}} F_{t-1} = -\Delta F_t,$$ (30)

where $NX_t$ is the net exports. Equation (29) is simply a variant of the basic national accounting identity, or decomposition of the gross domestic product (net of lost output) by expenditure approach. Equation (30) is the simplified balance-of-payments identity, which states that the combined current and capital account, comprised of net exports and net financial income from abroad in this simple economy, must equal the financial account, or in this case simply the change in foreign debt. Derivation of the well-known macroeconomic identities from sectoral balance sheets and budget constraints is economically important in that it confirms the micro-macro consistency of the model and helps to draw parallels with the empirical analysis of integrated economic and financial accounts (see Section 3.5).

Finally, we need one more equation to identify the price level and close the model. As was mentioned above, the standard closure using the Taylor rule is not appropriate for a small member state of a monetary union, in which the monetary policy does not actually react to changes in that specific economy. We therefore assume that the domestic price level is determined by external competitiveness similarly to Vītola and Ajevskis (2011)

and Aoki, Benigno, and Kiyotaki (2018). To this end, we endogenize net exports to be a function of the price level and consumption:

$$NX_t = n_1 P_t^{-n_2} - n_0 C_t. \tag{31}$$

External competitiveness, and net exports in particular, is assumed to be negatively linked to the real exchange rate, determined solely by the domestic price level, since the exchange rate and foreign price levels are both exogenously fixed. Also, consumption negatively affects net exports through imports channel.

This completes the model. A full list of model equations is presented in Appendix 4.

### 3.5. Dual financing mechanism and feedback cycle of financing

The model design captures two potentially very different financing mechanisms. One is related to household's decision to allocate existing purchasing power between consumption and financial saving and the other one is linked to bank's willingness to create new purchasing power. The two decisions jointly determine the supply of credit to the economy and greatly affect the economic dynamics as will be shown in a later section. The whole process could be schematically visualized with the help of the analytical integrated economic and financial accounts table. In Table 1 we see an example of such a table adapted for our simple model economy. We will now briefly discuss it (for a more detailed discussion see Ramanauskas et al., 2016a).

Table 1 summarizes economic and financial transactions among the four institutional sectors of our model economy and the rest of the world. It is expressed in nominal terms. Starting from the top of the table, it reflects the relationship between gross domestic product and gross disposable income. Going horizontally, it shows sectoral distribution of gross national disposable income. Subtracting consumption expenditure from sectoral disposable income gives sectoral saving. Subtracting further investment spending, one gets sectoral nonfinancial balances or net lending balances – roughly speaking, income left over after all economic spending. These were transactions recorded in the economic accounts. Going further down we see financial accounts. Thus, net sectoral lending (or borrowing) must equal a change in net sectoral financial assets, and

**Table 1.** A simplified representation of the financing cycle in the analytical integrated accounts table.

| | Economy | Households | Firms | Banks | ROW |
|---|---|---|---|---|---|
| GDP | $P \cdot Y$ | | | | |
| Primary income balance | $-R_F F - DivB$ | | | | $R_F F + DivB$ |
| Gross national income | | | | | |
| Secondary income balance | | | | | |
| Gross national disposable income | $Y_D = P \cdot Y - R_F F - DivB$ | $Y_{D,H}$ | $Y_{D,F}$ | $Y_{D,B}$ | |
| Minus consumption | $-P \cdot C$ | $-P \cdot C$ | | | |
| Savings | $S = Y_D - P \cdot C$ | $S_H = Y_{D,H} - P \cdot C$ | $Y_{D,F}$ | $Y_{D,B}$ | |
| Minus investment | $-P \cdot I$ | | $-P \cdot I$ | | |
| Current account balance (net exports plus income balance) | $CAB = S - P \cdot I$ $= P \cdot NX - R_F F - DivB$ | | | | $-CAB$ |
| Capital account balance | | | | | |
| Financial account balance (net lending) | $NL = CAB$ | $NL_H = S_H$ | $NL_F = Y_{D,F} - P \cdot I$ | $NL_B = Y_{D,B}$ | $-NL$ |
| Change in bank loans | 0 | | $-\Delta L_F$ | $\Delta L_F$ | |
| Change in bank deposits | 0 | $\Delta D_H$ | | $-\Delta D_H$ | |
| Change in bank foreign liabilities | $-\Delta F$ | | | $-\Delta F$ | $\Delta F$ |
| Bank loans | | | $-L_F$ | $L_F$ | |
| Bank deposits | | $D_H$ | | $-D_H$ | |
| Foreign debt | $-F$ | | | $-F$ | |
| Financial net worth | $-F$ | $D_H$ | $-L_F$ | | |

financial accounts simply detail the changes in composition of these financial assets. For example, if the household sector is spending less that its disposable income in our model, it must be accumulating financial assets in the form of deposits. In addition to recording financial flows, the stocks of financial variables are also tracked. All in all, we have a closed and fully stock-flow consistent integrated accounts table as the analytical representation of our DSGE model.

The arrows in Table 1 show the stylized feedback cycle of financing (omitting a number of channels, for expositional simplicity), which is crucial for understanding the feature of partial self-financing of bank credit. In this stylized representation, the bank decides how much credit to provide to finance firm's investment. Investment affects economic activity and household's disposable income. The household determines how much to spend and how much to save in the form of deposits. Household's and firm's spending decisions affect the trade balance and the economy's external financing needs. Household deposits and bank's borrowing from abroad serve as the main sources of financing for the bank. In a nutshell, bank lending creates money, which is used to settle economic transactions and at the end of the day shows up in the form of deposits, and they in turn serve as one of the main sources of bank financing, thereby creating the financing feedback loop.

## 4. Calibration

We calibrate the model's parameters to broadly match some general macroeconomic ratios (Table 2) of the Lithuanian economy at annual frequency for the period of 2004–2018. The calibrated parameter values are presented in Table 3 which we discuss in this Section.

The numerical values for $\beta_F$, $a$, $\varepsilon$, $\delta$, and $\eta_K$ are chosen simultaneously to produce the following steady-state ratios: bank loans to GDP ratio of 66%, investment to GDP ratio of 20%, the capital share in aggregate income of 31%[5] and firms' return on equity of 8.3%, in line with the corresponding historical averages in Lithuania. The calibrated value of $\varepsilon$, the elasticity of demand for intermediate goods, directly implies a mark-up of 3%. LTV cap parameter $\eta_K$ gives the firms' equity to liabilities ratio of 1.5, which is close to the long-term average figure from the national accounts.

The investment adjustment cost parameter $\psi_I = 0.63$ is taken from the Bayesian mean estimate in Vītola and Ajevskis (2011). The price adjustment cost parameter $\psi_P = 95$ in our model would correspond to a 75% chance that prices will remain unchanged in a given quarter – a typical probability in models with Calvo pricing.

**Table 2.** Matched steady-state ratios.

| Variable | Interpretation | Value (%) |
|---|---|---|
| $L_F/PY$ | Bank loans to GDP ratio | 66 |
| $I/Y$ | Investment share | 2 |
| $WL/PY$ | Labour compensation share | 69 |
| $\pi/\Pi$ | Firm's ROE | 8.3 |
| $\Pi/L_F$ | Firm's equity to liabilities ratio | 150 |
| $r_D$ | Interest rate on deposits | 1.3 |
| $r_L$ | Interest rate on bank loans | 4.2 |
| $\mu$ | Bank capital requirement | 14.5 |
| $CR$ | Bank capital adequacy ratio | 19 |
| $\omega$ | Average bank risk weight | 70 |
| $r^*$ | Risk-free interest rate | 1.06 |
| $F/PY$ | Bank external debt to GDP ratio | 14.5 |

**Table 3.** Calibrated parameter values.

| Parameter | Description | Value |
|---|---|---|
| $a$ | Capital share in the production | 0.29 |
| $\delta$ | Depreciation rate for physical capital | 0.12 |
| $\varepsilon$ | Price elasticity of demand for intermediate goods | 34 |
| $\eta_K$ | Loan to value cap for firms loans | 0.4 |
| $\psi_P$ | Price adjustment costs parameter | 95 |
| $\psi_I$ | Investment adjustment costs parameter | 0.63 |
| $\beta_F$ | Firm's discount rate | 0.949 |
| $\beta$ | Households' discount rate | 0.987 |
| $\sigma_L$ | Weight of labour disutility in households' preferences | 0.887 |
| $\gamma$ | Capital buffer financial cost parameter | $3.981 \times 10^{-3}$ |
| $\omega$ | Average risk weight | 0.7 |
| $\mu$ | Minimum capital adequacy ratio | 0.145 |
| $\beta_B$ | Banker's discount rate | 0.878 |
| $\phi_0$ | Risk-free interest rate effect on $r_{F_t}$ | 0.715 |
| $\phi_1$ | Foreign indebtedness effect on $r_{F_t}$ | 1.818 |
| $n_0$ | Imports to consumption share | 0.9 |
| $n_1$ | Constant net exports demand | 1.8 |
| $n_2$ | Price elasticity of net exports demand | 1 |

The households' discount factor $\beta = 0.987$ corresponds to the historical average nominal interest rate on private sector deposits (including both sight and term deposits) of 1.3%. $\sigma_L$ is selected so that steady-state labour would be equal to unity.

The value of $\gamma$, governing the financial cost associated with a thin capital buffer, is consistent with the historical average of nominal rates on loans to the private sector, which is equal to 4.2%. The combination of the willingness to hold the capital buffer, governed by parameter $\gamma$, and banker's impatience parameter $\beta_B = 0.878$ determines the steady-state level of bank capital held, which is set in line with the typical post-crisis capital ratio of 19% and the required minimum level of about 14.5% (which includes both Pillar I and Pillar II capital requirements). The risk weight parameter $\omega = 0.7$ corresponds to the average risk weight for banks operating in Lithuania. Foreign financing supply parameters $\phi_0$ and $\phi_1$ are calibrated to make bank's foreign debt to GDP ratio equal to 14.5%, as Lithuanian banks' gross foreign debt fluctuated around that level in the post-crisis period.

Turning to the parameters related to the foreign trade, the parameter $n_0 = 0.9$ reflects the historical average imports to consumption ratio in Lithuania. As there is little empirical evidence about the long-term equilibrium level of trade balance, we arbitrarily choose the parameter $n_1$ to ensure that in the steady state there is a small trade surplus, which would offset financial outflows in the form of bank dividends and interest rate payments on foreign debt (resulting in the balanced current account in the steady state). The value of the parameter $n_2$, governing the price elasticity of net exports, is set equal to 1, like in Vītola and Ajevskis (2011) and Aoki et al. (2018).

## 5. Shock analysis

In this section we study responses of the system to unexpected, permanent deterministic shocks, namely, banker's preference, household's preference, capital requirement and risk-free interest rate shocks. The joint the analysis of banker's preference and household's preference shocks sheds light on the functioning of the mechanism of bank credit and money creation and helps to contrast it with intermediation of loanable funds. The remaining shocks are quite standard.

### 5.1. Shocks to bank's willingness to lend and household's willingness to save

Here we focus on the detailed comparison of the ILF bank and the FMC bank and highlight the fundamental differences between the two modes of financing that arise in short- and medium-term. Also, the analysis of model responses to shocks to households' willingness to save and bank's willingness to lend reveals that savings-based financing and credit-based financing are also fundamentally different and thus cannot be conflated in the policy-relevant analysis, e.g. by abstracting from the banking sector and focusing solely on household saving.

To analyse the mechanism of credit and money creation we induce an unexpected, permanent deterministic shock to banker's (subjective) willingness to lend. This is done by shocking parameter $\psi_{Lf,t}$ in banker's utility function (see Appendix 2), which governs a subjective utility derived from the size of the bank's loan portfolio. As a result of the shock, the banker is suddenly willing to expand the loan portfolio as he can thereby attain higher utility. For ease of comparison with the household preference shock discussed below, the size of the banker's preference shock is calibrated so that the resultant impulse response function (IRF) of deposits would reach a value of 1% at the end of a 20-year horizon.

We should also clarify the distinction between the flexible-price case and the fixed-price case. The flexible-price case is simply the model presented above, with price adjustment costs and other rigidities. The fixed-price case is obtained by exogenizing prices (setting them equal to a constant). As a consequence, external competitiveness Equation (31), used to identify endogenous prices, becomes redundant and needs to be removed from the model. It can be shown that this is equivalent to leaving endogenous prices in the model but at the same time imposing a very high negative elasticity of net exports to prices (by assigning a sufficiently high value to parameter $n_2$ in Equation (31)). In other words, the fixed-price case represents the situation in which final goods markets are fully integrated internationally and the price of the final product cannot be raised above the foreign price level because imports would immediately replace domestic goods. Also note that even though external competitiveness equation is removed, net exports are still determined endogenously in the model as a variable balancing domestic demand ($C+I$) and aggregate supply ($Y$). Thus, if domestic demand is higher than the aggregate supply, the excess demand is simply satisfied by importing foreign goods at the prevailing market price (which is equal across the countries). Similarly, excess domestic production can be exported at the prevailing price.

### 5.1.1. Banker's preference shock in the fixed- and flexible-price settings

We start with the fixed-price case, in which the bank is dealing with real resources and which actually represents the ILF paradigm. In response to the preference shock, the banker increases supply of loans (see Figure A1 in Appendix 1). More active financial intermediation effectively means lower financial frictions, thus over the long run the economy transitions to the new steady state of higher economic activity. Let's examine the process of transition more closely. To accommodate stronger loan supply, loan rates immediately fall. There is a strong concurrent rise in corporate investment, leading to a rapid accumulation of capital. Nevertheless, firms are rather slow to increase production because the rest of the economy is initially quite sluggish. To satisfy the increased domestic

demand, and in the short- and medium-term the economy heavily relies on increased imports. Even though the lower cost of external financing and a gradual increase in sales provide a boost to firm profits over the medium term, initially they are forced to with-hold dividend pay-outs. The reason is that firms need to adhere to the LTV constraint (i.e. keep the financial leverage stable) and therefore try to retain earnings. Slow growth of productive activities result in lacklustre growth of wage income. This, together with withheld dividend pay-outs, results in a somewhat sluggish household income dynamics over the medium term. At the same time, household consumption expenditure rises slightly more rapidly, driven by rational expectations of better economic prospects. Since household spending outpaces income growth, the household is forced to dip into its savings over the short and medium term, thereby temporarily driving down deposits. Importantly, the bank faces a large financing gap, as the loan portfolio increases and there is a simultaneous drawdown of deposits. The bank tries to remedy the situation by modestly raising deposit rates but since it is not possible to balance its books this way, it is forced to step up very significantly borrowing from abroad (recall that at the same time imports rise significantly). Suppression of interest rate margins has a strong negative impact on bank profits. The bank also has to significantly reduce dividend pay-outs in order to strengthen its capital and support the balance-sheet expansion. Over the long term, as the economy moves to the new steady state of higher economic activity, the bulk of the increase in foreign debt gets gradually repaid and replaced with deposits. All in all, in the fixed-price setting the bank is able to extend new credit and raise deposits, but only with the help of large interim financial injections from abroad. The dynamics of deposits is distinctly different from that of loans over the short and medium term.

Turning to the flexible-price setting, we can immediately see from Figure A1 in Appendix 1 that in response to the bank's preference shock real variables tend to converge to the same new steady-state levels as in the fixed-price setting but the transition dynamics can be very different. Now that the prices are allowed to vary, we have to distinguish between nominal and real variables. As before, in response to the increased loan supply, loan rates fall substantially both in nominal and real terms. Firms again step up investment spending in response to cheaper external financing and in anticipation of stronger economic activity in the long term. In contrast to the fixed-price case, firms can now increase prices and earn higher profits in the short term, and instead of relying on larger imports, firms immediately ramp up domestic production.[6] In order to achieve this, firms have to significantly increase (both nominal and real) wages and attract more labour. This has a crucial positive impact on household income in the medium term. At the same time, real consumption remains slightly subdued against the background of an increase in prices. Household's (nominal) disposable income rises more strongly than (nominal) consumption expenditure and this leads to a commensurate increase in bank deposits – in a stark contrast to the fixed-price case. Note that the amount of newly created money in the form of deposits is very much in line with an increase in bank loans. Bank's books are nearly balanced, thus the bank has virtually no need to resort to foreign financing or raise nominal deposit rates – a remarkable difference from the fixed-price case and clear evidence of self-financing credit expansion at the (subjective) will of the banker! Of course, the bank still needs to raise equity, which it does by withholding dividends, to support the leveraged balance-sheet expansion.

To summarize system responses to the bank's preference shock, in both fixed-price and flexible-price settings the economy moves to the new steady state associated with higher

economic activity. However, the transition path is very different. The visual comparison of the evolution of bank's balance-sheet is provided in the contribution charts (see Figure 2). In the fixed-price setting, the bank is unable to create real resources and thus credit issuance is effectively associated with intermediation of real resources, which depletes deposits and immediately creates the financing gap. The bank is forced to close the gap mainly by temporarily resorting to foreign funding. In the flexible-price setting, the bank is operating in nominal terms. In this case the bank is able to create nominal purchasing power, which stimulates both price rises and real economic activity. In other words, we observe a much stronger impact on domestic demand as compared to the fixed-price case. A large part of the newly created money remains in the system in the form of deposits and ensures a nearly balanced bank's balance-sheet and bank's effective independence from foreign financing. Also note that even though bank credit can be largely self-financing (i.e. can be financed with the deposits created in the process of credit issuance), the actual willingness to create credit should mainly depend on profitability prospects. In this simple model 'excess' credit is associated with bank losses, whereas in reality excessive bank credit is likely to stimulate various bubbles (for example, a property price bubble) opening possibilities for banks' oversize profits in the short and medium term. Overall, the shock analysis confirms the assertions by Borio and Disyatat (2011) that the financial system typically is highly elastic and bank credit issuance is mostly determined by profitability prospects.

### 5.1.2. Household's preference shock

In the previous subsection we focused on the mechanism whereby banks provide financing through money creation. Now we can contrast the outcome of bank's stronger willingness to lend with the situation, in which the household is more willing to save and provides more savings to the banking system. The shock to the household's willingness to save is introduced by permanently increasing household's patience by increasing $v_t$. As was mentioned above, the size of the shock was calibrated so as to ensure that the savings-based long-term change in deposits would be equal 1%. Owing to this calibration,
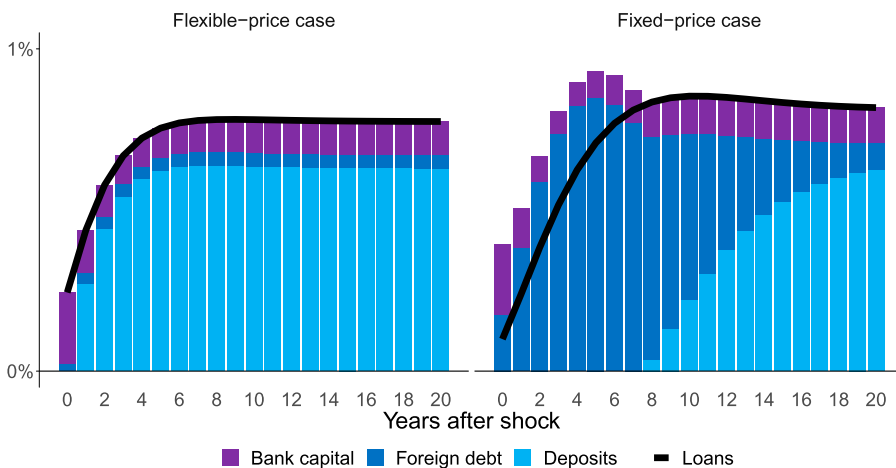


**Figure 2.** Contributions to bank balance sheet expansions in response to increased bank's willingness to lend in the flexible- and fixed-price settings.

we can compare what it takes to a certain increase in deposits with bank credit and out of savings. We can also examine if the bank is willing to 'intermediate' the extra savings.

Higher household saving implies postponed consumption and lower domestic demand in the short and medium term (see Figure A2 in Appendix 1). Increased supply of savings in the form of deposits puts a downward pressure on deposit rates and the impact is passed through on loan rates. Firms face a 'hole' in domestic consumption expenditure but they are able to utilize their production capacity by selling the final product abroad. Given price and wage deflation, exports increase quite strongly in the short and medium term, bolstering firm profitability and credit demand. As a result, bank credit increases albeit to a much smaller extent than deposits, which shows that the bank is generally unwilling to 'intermediate' savings. The bank uses the bulk of excess financing in the form of deposits to strongly reduce its foreign debt. Over time, as saving bolsters household's income, real consumption rises to higher than pre-shock levels, thereby reducing economy's reliance on exports.

To summarize, there are essential differences between the two shocks and two very distinct financing channels that these shocks represent. If the bank credit shock had an inflationary impact (at least in the short term), the shock to the household's willingness to save is deflationary. The credit shock stimulates domestic demand and the impact is most potent if domestic producers have the capacity to satisfy additional demand. In contrast, the household saving shock initially depresses domestic demand and works best if the economy has the ability to take the benefit of improved external competitiveness and can export excess production. We can generalize these insights beyond our simple model. The model shocks illustrate two very different ways to stimulate the economy, say, in the aftermath of a crisis. One way is to stimulate domestic demand by creating new purchasing power by resorting to bank credit, monetary financing of government debt or government's borrowing from abroad. The other way is to impose austerity on private or public spending, suffer through the period of depressed domestic demand, repay external debt and try to achieve recovery by relying on stronger exports.

## 5.2. Shock to risk-free interest rate

We now induce an unexpected permanent 0.1 p.p. shock to the risk-free rate $r_t^*$, which can be loosely interpreted as an exogenous monetary policy shock.[7] In the long term, the economy shows a small contractionary reaction to the adverse interest rate shock, as one would expect. However, in the short and medium term the reaction can be very different (at least for the current parametrization of the model), as the previously discussed effect of stronger household saving kicks in.

The risk-free interest rate shock invokes an immediate increase of almost the same magnitude in the interest rate on foreign debt,passed through onto deposit rates and loan rates (see Figure A3 in Appendix 1). There is a sudden drop in the price level, which amplifies the interest rate change in real terms. This in turn strongly increases the household's propensity to save, bringing down real consumption expenditure. To stabilize the drop in consumption, the household is willing to supply more labour services, which brings down real wages. Against the background of weak domestic demand, the firm starts to more actively rely on exports, which are also positively affected by improved price competitiveness. Export-led growth contributes to the positive medium-term

dynamics of real investment, firm profitability and dividend pay-outs. As a result of larger income from firm ownership, household's income increases quite significantly and, coupled with subdued consumption expenditure, results in a strong rise of household's bank deposits. This in turn allows the bank to strongly reduce its reliance on foreign debt. Deposit and loan rates gradually return to initial values, and so does real consumption. However, since capital and labour variables end up at slightly lower new steady-state levels, the new steady-state level of economic output is also lower than the pre-shock level.

### 5.3. Shock to bank capital requirement

As a final experiment, we consider a shock to the bank capital requirement whereby the required capital ratio parameter $\mu$ is permanently increased by 1 p.p. This shock is interesting from the macroprudential policy perspective. For this reason, in this case we pay closer attention to the assessment of model responses.

   The capital requirement shock in this simple model without credit risk can be simply seen as a larger imperfection of the financial market, therefore it generally produces negative effects on economic activity (see Figure A4 in Appendix 1). First of all, there is a nearly one-to-one increase in the actual capital held by the bank as it tries to maintain sufficiently comfortable capital buffers. Since the bank is not allowed to raise equity in the market in this model, it has to bolster its capital position from internal resources. For this, the bank immediately widens its lending margins. Deposit rates would stay virtually unchanged but the immediate impact on loan rates could reach up to 0.4 p.p. It should be noted though that we do not have interest adjustment costs in the model, unlike e.g. Gerali et al. (2010), therefore the immediate response is rather large and may overestimate the actual response. The more reasonable short-term impact could be obtained by taking a three-year average, which would give an increase of 0.26 p.p. in loan rates. The long-term impact on loan rates amounts to 0.09 p.p. The loan portfolio is estimated to contract by 0.3% in the long term. The change in financing conditions would negatively affect annual figures of real investment and consumption by 0.3% and 0.1% respectively. Real GDP would permanently decline by 0.08%, relative to the baseline. There is a temporary deflationary pressure, with prices dipping by less than 0.1% from the baseline at the lowest point. As household's wages and dividends fall even more than nominal consumption expenditure, the household's savings in the form of deposits decline by 1.5% in the long term. Looking from the bank's perspective, it is forced to slightly reduce the size of its balance-sheet and significantly reduce leverage. Thus, it offsets the decline in deposits with accumulated equity, which rises by some 5% relative to the baseline. Quite surprisingly, bank's profits and dividend pay-outs increase by about 5%, as the bank succeeds in ensuring the unchanged return on equity. Technically, the bank is able to reap larger profits because, against the background of higher rates on loans, it replaces costly deposits with retained earnings, which do not weigh on the bottom line of the P&L account.

   All in all, the macroprudential capital requirement shock slightly hampers economic activity and creates very mild and temporary deflationary pressures. Investment and bank deposits are among the variables to bear the largest impact of the shock. Bank profits, somewhat counter-intuitively, might even increase (bear in mind that they are

not allowed to finance bubble-like investment in this model, and if they were, this could potentially change this conclusion).

## 6. Conclusions

In this paper we take a thorough look at the creation of money and purchasing power by banks in a fully-fledged macroeconomic setup. Our paper is one of the few studies, in which the DSGE framework is applied to specifically study bank credit issuance and money creation. We show that a simple DSGE model is capable of representing banks as genuinely monetary institutions and allows capturing credit and money creation in line with the FMC predictions. The emphasis in our model is on having a quite standard closed dynamic system with a set of microeconomic and macroeconomic constraints, a bank with a separate balance sheet and autonomous decision making power, a simple form of heterogeneity and, importantly, prices and the price identification mechanism.

By analysing a sudden unexpected change in bank's willingness to lend, we show that in the nominal setting the bank is capable of extending credit and fostering permanently higher economic activity without the need to raise deposit rates or actively attract financial resources from abroad. As a result of credit issuance at the will of the banker, deposits are created in the model economy and their dynamics is very similar to that of credit. And, in a stark contrast, this is not case if the bank operates in the fixed-price environment – in that case the bank needs to raise deposit rates and is still very much reliant on attracting additional financial resources. These findings provide theoretical support to what is known as a high elasticity of the financial system, or the feature that bank credit is at least partly self-financed. We also show that there are constraints to credit creation, and they are first and foremost related to banks' profitability considerations. In our simple, bubble-free model economy 'excessive' bank credit leads to bank losses, which is what prevents banks from overextending credit.

A major macroeconomic implication of banks' ability to create money and purchasing power is the immediate contribution of a credit shock to aggregate demand, nominal incomes, output and price pressures. With the help of our theoretical model we show that one can view bank credit as a powerful monetary stimulus over the short and medium term and argue that economic developments must be analysed in conjunction with the analysis of credit developments.

In the paper we also draw a clear distinction between a saving-based and bank credit-based financing, or, in other words, household's willingness to save and bank's willingness to lend. These two financing mechanisms, which often tend to be conflated by economic observers and policymakers alike, ultimately stimulate economic activity, but in very different ways. A shock to the household's willingness to save, akin to austerity policies, induces deflationary pressures, depressed domestic demand, stronger exports, foreign debt repayment and just a fractional increase in bank lending. In contrast, a shock to bank's willingness to lend creates inflationary pressures, higher domestic demand, stronger imports and a quite balanced expansion in both bank loans and deposits.

We also employ our calibrated model to obtain quantitative predictions of the Lithuanian economy's response to the macroprudential policy shock whereby the minimum bank capital requirement is permanently increased by 1 p.p. The shock slightly hampers economic activity, which permanently declines by 0.1% from the baseline in the long run, and creates

mild and temporary deflationary pressures. In the long term, loan rates could permanently increase by less than 0.1 p.p., whereas the short-term impact could be several times higher. Corporate investment and bank deposits are among the variables to bear the largest impact of the shock – over the long term real investment could decline by 0.3% from the baseline, whereas the stock of deposits could be negatively affected by 1.5%.

Going forward, we deem this area of research very relevant, challenging and promising. It is crucial for economists and policymakers to deepen their understanding and dispel the prevalent myths about the role of banks in the macroeconomy, and this can have immense implications for the understanding of the functioning of the economy as a whole. With regard to the current model, it could be improved in a number of ways to make it more applicable for policy analysis. In particular, we will be working on incorporating credit risk, adding the missing institutional sectors and financial assets (e.g. government sector and government bonds), as well as including the housing market and mortgage lending.

## Notes

1. See Jakab and Kumhof (2015) for a detailed discussion of the FMC view and the critique of the prevailing ILF view.
2. For example, not once is this fact mentioned in the comprehensive treatise on the contemporary banking theory by Freixas and Rochet (2008).
3. Some of the few models that deal with small open economies with banking sectors, which also share some features with our model, include models for Ireland by Clancy and Merola (2017) and Lozej et al. (2017) and a model for Latvia by Vītola and Ajevskis (2011).
4. Notably, unlike Jakab and Kumhof (2015) we don't find it necessary to allow borrowers to simultaneously take bank loans and hold deposits or explicitly record a bank loan as a newly created deposit in the borrower's account. Though banks credit borrowers' accounts with newly created money (and, as a result, borrower's deposits increase within a time period), we make a simplifying assumption that the borrower uses all those funds for settlements or debt repayment and the end-of-period balance of the borrower's deposit account is always zero. Therefore in the formulation of our model the borrower (firm) is not allowed to have deposits.
5. The empirical counterpart is calculated by adding to gross capital consumption a halved sum of gross operating surplus and mixed income. The estimate is close to the estimates of 0.297 and 0.32 obtained, respectively, by Karpavičius (2008) and Proškutė (2012).
6. The size of the immediate shock impact on real activity is positively linked to price adjustment costs. But even in the absence of adjustment costs the central result that bank lending is largely self-financing still holds.
7. A note of caution with this interpretation is in place because this shock, unlike a genuine monetary policy shock in a monetary union, does not adversely affect aggregate demand in the 'rest of the world'. Thus, in our case the model predicts quite positive medium-term developments related to the export-led growth.

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## Disclosure statement

No potential conflict of interest was reported by the authors.

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## References

Adrian, T., & Shin, H. S. (2010). Financial intermediaries and monetary economics. In B. M. Friedman & M. Woodford (Eds.), *Handbook of monetary economics* (Vol. 3, Chap. 12, pp. 601–650). Amsterdam: Elsevier.

Aoki, K., Benigno, G., & Kiyotaki, N. (2018). *Monetary and financial policies in emerging markets*. Manuscript available.

Beneš, J., & Kumhof, M. (2012). *The Chicago plan revisited* (IMF Working Papers 12/202). International Monetary Fund.

Beneš, J., Kumhof, M., & Laxton, D. (2014a). *Financial crises in DSGE models; A prototype model* (IMF Working Papers 14/57). International Monetary Fund.

Beneš, J., Kumhof, M., & Laxton, D. (2014b). *Financial crises in DSGE models; Selected applications of MAPMOD* (IMF Working Papers 14/56). International Monetary Fund.

Bernanke, B. S. (2005). *The global saving glut and the U.S. current account deficit*. Speech 77, Board of Governors of the Federal Reserve System (U.S.).

Bernanke, B., Gertler, M., & Gilchrist, S. (1999). The financial accelerator in a quantitative business cycle framework. In J. B. Taylor & M. Woodford (Eds.), *Handbook of macroeconomics* (Vol. 1, Part C, Chap. 21, pp. 1341–1393). Amsterdam: Elsevier.

BIS (2016). *86th annual report* (Annual report). Bank for International Settlements.

Boissay, F., Collard, F., & Smets, F. (2016). Booms and banking crises. *Journal of Political Economy*, *124*(2), 489–538.

Borio, C. (2011). *Rediscovering the macroeconomic roots of financial stability policy: Journey, challenges and a way forward* (BIS Working Papers 354). Bank for International Settlements.

Borio, C. (2012). *The financial cycle and macroeconomics: What have we learnt?* (BIS Working Paper No. 395).

Borio, C., & Disyatat, P. (2011). *Global imbalances and the financial crisis: Link or no link?* (BIS Working Paper No. 346).

Clancy, D., & Merola, R. (2017). Countercyclical capital rules for small open economies. *Journal of Macroeconomics*, *54*(PB), 332–351.

Clerc, L., Derviz, A., Mendicino, C., Moyen, S., Nikolov, K., Stracca, L., Suarez, J., & Vardoulakis, A. P. (2015). Capital regulation in a macroeconomic model with three layers of default. *International Journal of Central Banking*, *15*(3), 9–63.

Cúrdia, V., & Woodford, M. (2009). *Credit frictions and optimal monetary policy* (BIS Working Paper No. 278).

Disyatat, P. (2008). *Monetary policy implementation: Misconceptions and their consequences* (BIS Working Papers 269). Bank for International Settlements.

Disyatat, P. (2011). The bank lending channel revisited. *Journal of Money, Credit and Banking*, *43*(4), 711–734.

Freixas, X., & Rochet, J.-C. (2008). *Microeconomics of banking* (2nd ed.). Cambridge, MA: The MIT Press.

Furfine, C. (2001). Bank portfolio allocation: The impact of capital requirements, regulatory monitoring, and economic conditions. *Journal of Financial Services Research*, *20*(1), 33–56.

Gerali, A., Neri, S., Sessa, L., & Signoretti, F. (2010). Credit and banking in a DSGE model of the euro area. *Journal of Money, Credit and Banking*, *42*(S1), 107–141.

Godley, W., & Lavoie, M. (2012). *Monetary economics: An integrated approach to credit, money, income, production and wealth* (2nd ed.). London: Palgrave Macmillan.

Goodfriend, M., & McCallum, B. T. (2007). Banking and interest rates in monetary policy analysis: A quantitative exploration. *Journal of Monetary Economics*, *54*(5), 1480–1507.

Goodhart, C., Tsomocos, D., & Shubik, M. (2013). *Macro-modelling, default and money* (FMG Special Papers sp224). Financial Markets Group.

Hart, O. D., & Zingales, L. (2011). *Inefficient provision of liquidity* (NBER Working Papers 17299). National Bureau of Economic Research.

Iacoviello, M. (2005). House prices, borrowing constraints, and monetary policy in the business cycle. *American Economic Review*, *95*(3), 739–764.

Iacoviello, M. (2015). Financial business cycles. *Review of Economic Dynamics*, *18*(1), 140–163.

IMF (2014). *Financial programming and policies*. Washington: International Monetary Fund.

Jakab, Z., & Kumhof, M. (2015). *Banks are not intermediaries of loanable funds – and why this matters* (Bank of England working papers 529). Bank of England.

Jordà, O., Schularick, M., & Taylor, A. M. (2017). Macrofinancial history and the new business cycle facts. *NBER Macroeconomics Annual*, *31*(1), 213–263.

Karpavičius, S. (2008). Calibrated DSGE model for the Lithuanian economy. *Pinigų studijos (Monetary Studies)*, Nr. 2:22–46.

King, M. (2012). Speech to the South Wales Chamber of Commerce at the Millenium Centre.

Kiyotaki, N., & Moore, J. (1997). Credit cycles. *Journal of Political Economy*, *105*(2), 211–248.

Lequiller, F., & Blades, D. (2014). *Understanding national accounts* (2nd ed.). Paris: OECD Publishing.

Lozej, M., Onorante, L., & Rannenberg, A. (2017). *Countercyclical capital regulation in a small open economy DSGE model* (Research Technical Papers 03/RT/17). Central Bank of Ireland.

McLeay, M., Radia, A., & Thomas, R. (2014). Money creation in the modern economy. Quarterly bulletin, Bank of England.

Meh, C., & Moran, K. (2010). The role of bank capital in the propagation of shocks. *Journal of Economic Dynamics and Control*, *34*(3), 555–576.

OECD (2017). *Understanding financial accounts*. Paris: OECD Publishing.

Proškutė, A. (2012). Business cycle drivers in Lithuania. *Pinigų studijos (Monetary Studies)*, Nr. 1:5–29.

Ramanauskas, T., Matkėnaitė, S., & Rutkauskas, V. (2016a). Application of the integrated accounts framework for empirical investigation of the economic and financial cycle in Lithuania. *Pinigų studijos (Monetary Studies)*, Nr. 1:61–79.

Ramanauskas, T., Matkėnaitė, S., & Rutkauskas, V. (2016b). Credit and money creation from the integrated accounts perspective. *Pinigų studijos (Monetary Studies)*, Nr. 1:5–29.

Schmitt-Grohé, S., & Uribe, M. (2003). Closing small open economy models. *Journal of International Economics*, *61*(1), 163–185.

Schularick, M., & Taylor, A. M. (2012). Credit booms gone bust: Monetary policy, leverage cycles, and financial crises, 1870–2008. *American Economic Review*, *102*(2), 1029–1061.

Spahn, P. (2014). *The bank lending channel in a simple macro model – How to extend the Taylor rule?* (ROME Working Papers 201409). ROME Network.

Turner, A. (2013). *Credit, money and leverage: What Wicksell, Hayek and Fisher knew and modern macroeconomics forgot*.

van den Heuvel, S. J. (2008). *Temporal risk aversion and asset prices*. Finance and Economics Discussion Series (2008-37).

Vītola, K., & Ajevskis, V. (2011). *Housing and banking in a small open economy DSGE model* (Working Papers 2011/03). Latvijas Banka.

Werner, R. A. (2014). Can banks individually create money out of nothing? – The theories and the empirical evidence. *International Review of Financial Analysis*, *36*, 1–19.

Wicksell, K. (1906). *Lectures on political economy, volume two: Money*. London: Routledge and Sons, Ltd.

Xu, T. T. (2012). *The role of credit in international business cycles* (Cambridge Working Papers in Economics 1202). Faculty of Economics, University of Cambridge.
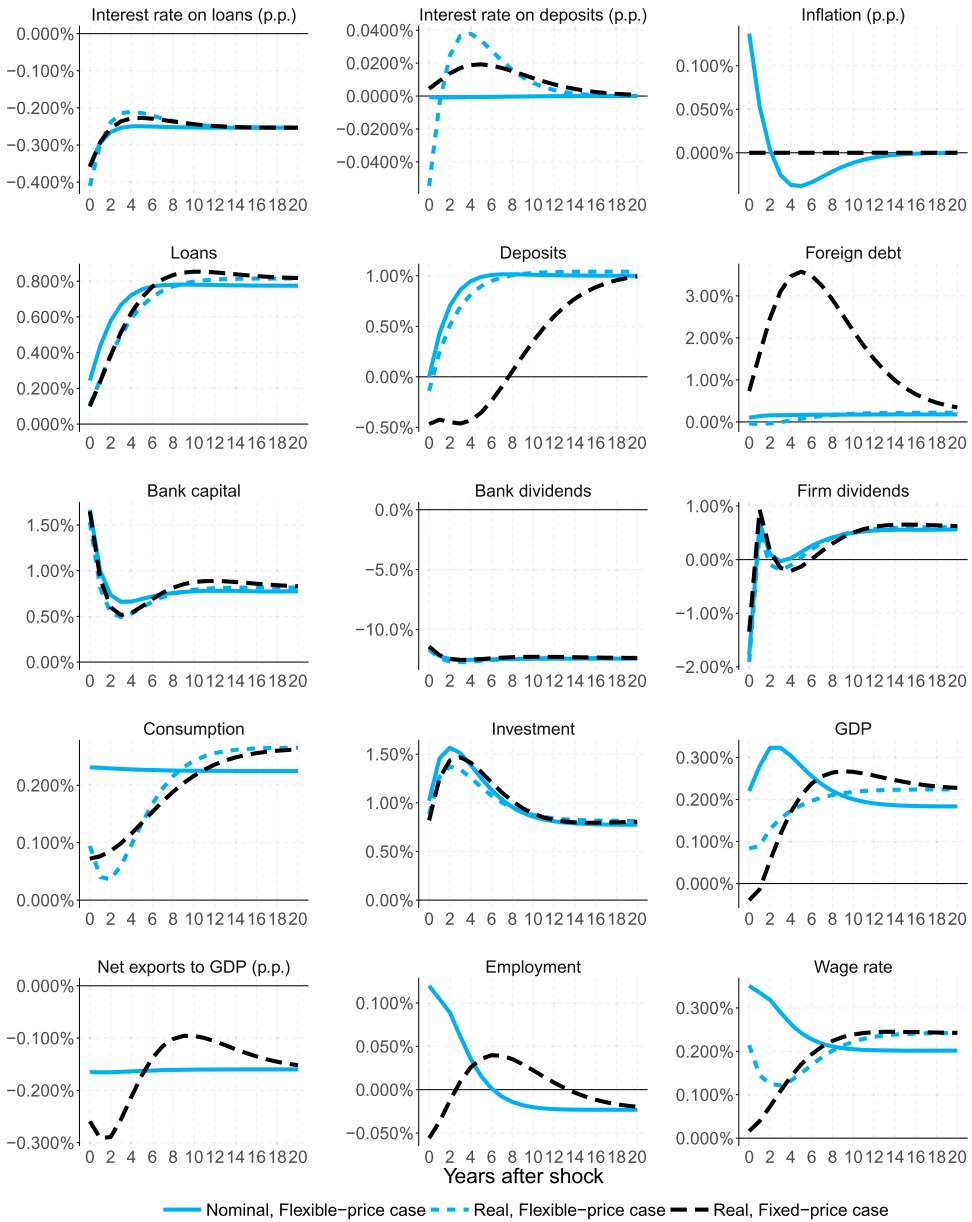
## Appendix 1



**Figure A1.** Responses to an unexpected increase in banker's willingness to lend.
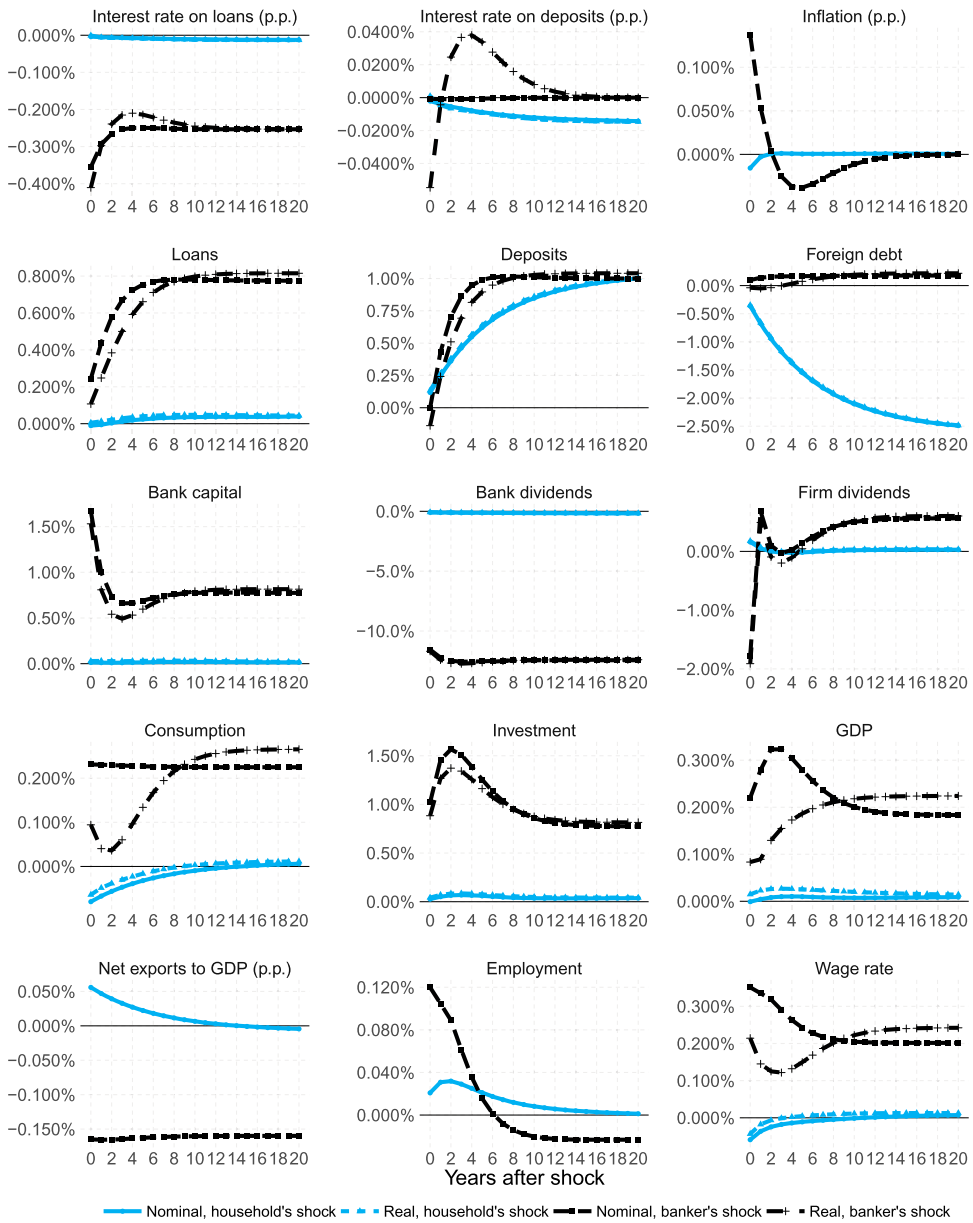
**Figure A2.** Responses to an unexpected increase in banker's willingness to lend and household's willingness to save.
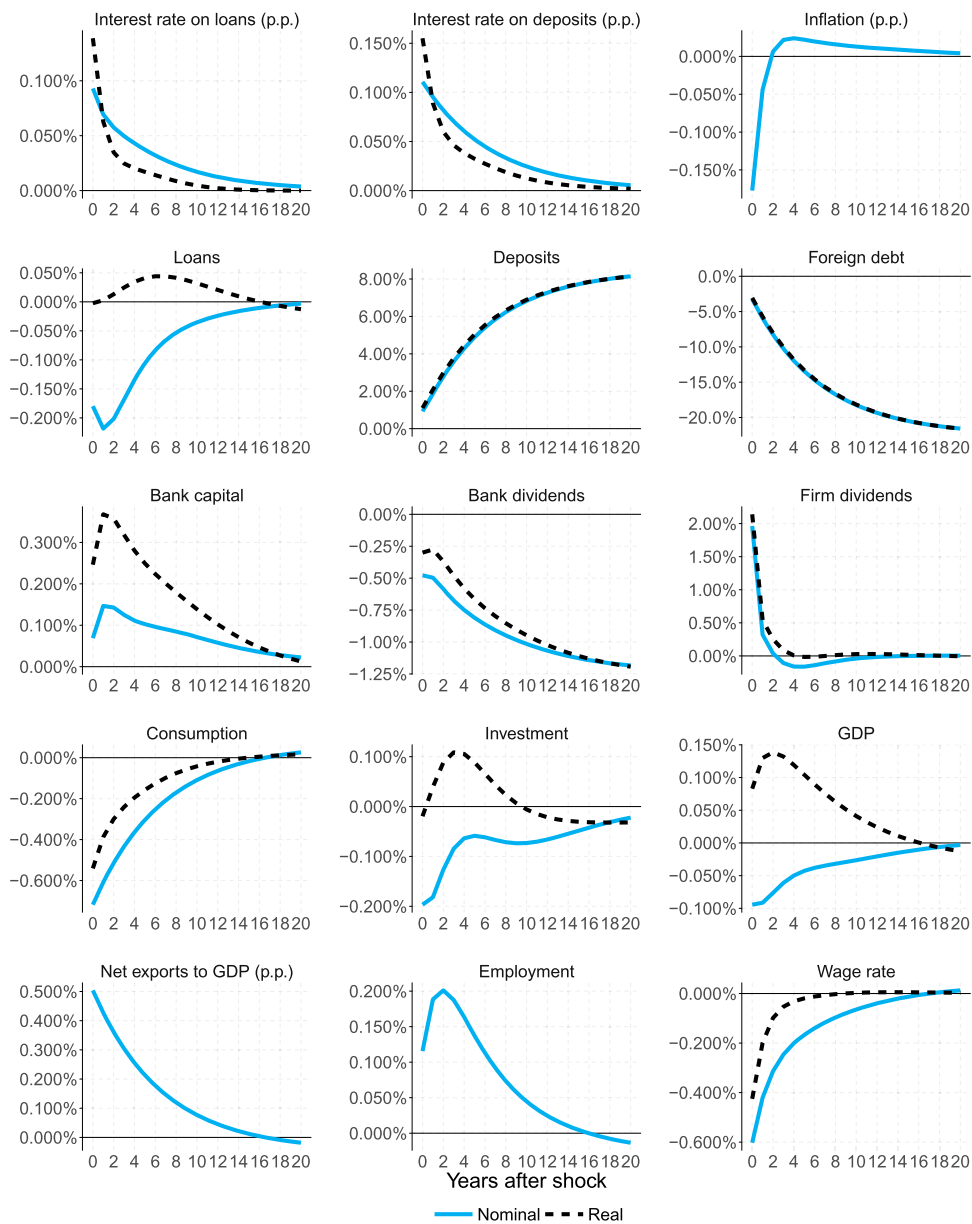
**Figure A3.** Responses to an unexpected and permanent rise in risk-free rate by 0.1 p.p.
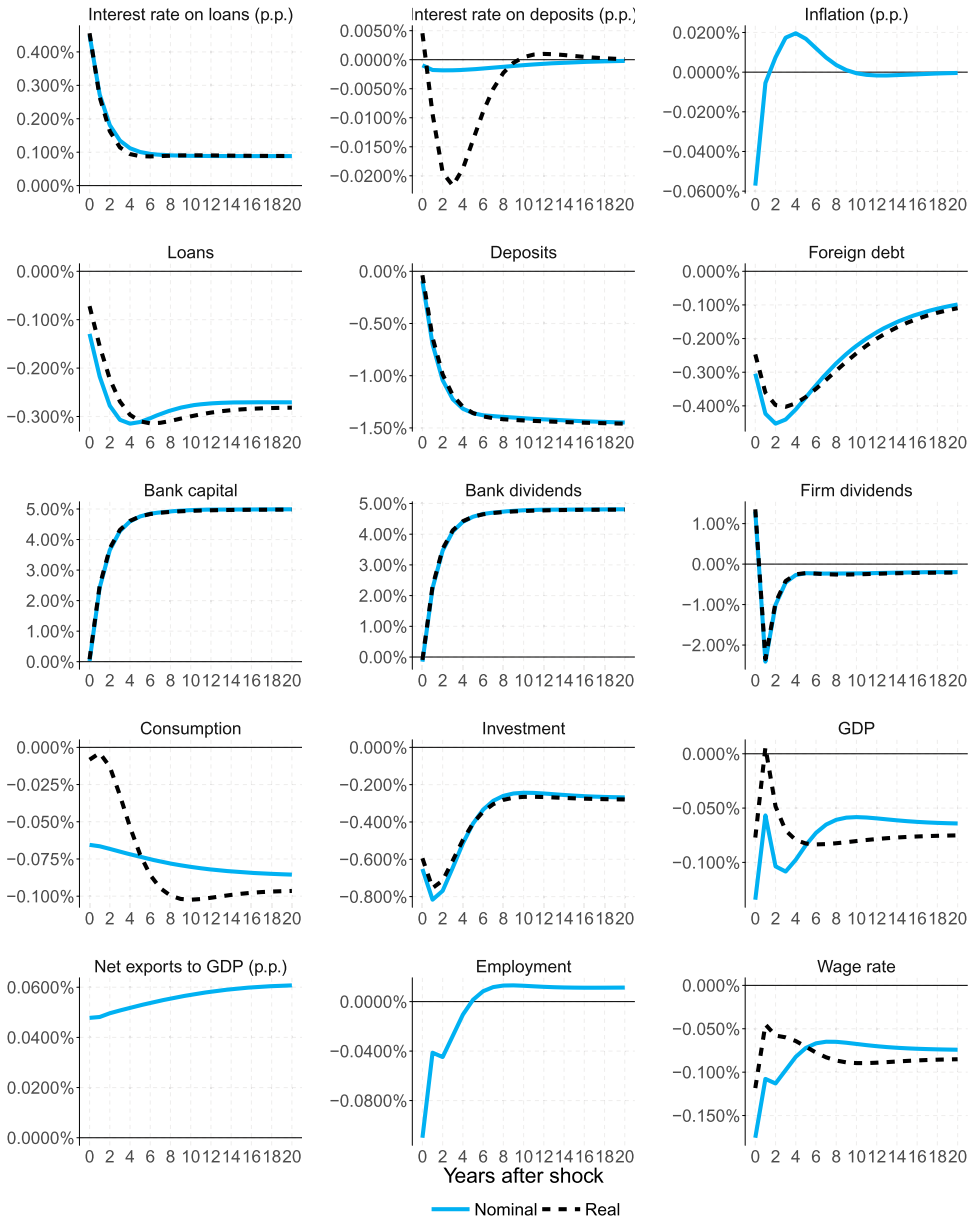
**Figure A4.** Responses to an unexpected and permanent rise in capital requirements by 1 p.p.

## Appendix 2

For the purpose of the shock analysis, we change slightly the formulation of banker's utility function by adding an additive term representing utility from loans:

$$\log C_t^* + \psi_{Lf,t} \log L_{F_t},$$

which is a loans-in-the-utility specification. Plugging the foreign banker's budget constraint into the specification above will produce

$$\log DivB_t - \log P_t^* + \psi_{Lf,t} \log L_{F_t}. \tag{A1}$$

We use this expression instead of using $\log DivB_t - \log P_t^*$ in the banker's maximization problem. This changes one of the banker's first-order conditions, namely, Equation (28) to the following:

$$\psi_{Lf,t} \frac{1}{L_{F_{t+1}}} + \beta_B \mathbb{E}_t\left[\frac{1}{DivB_{t+1}}\left(r_{L_t} - r_{D_t} - \gamma\left(\frac{E_t}{E_t - \mu_t \omega L_{F_t}} - \log\left(\frac{E_t}{\omega L_{F_t}} - \mu_t\right)\right)\right)\right] = 0. \tag{A2}$$

We set $\psi_{Lf,t}$ to zero in the steady state and exogenously shock it.

## Appendix 3

Here we state all Lagrangian functions in each agent/sector's problem. The patient household's Lagrangian function is

$$\mathcal{L}_H = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t v_t \left(U(C_t, L_t) + \lambda_{H,t}\left(P_t C_t + D_{H_t} - (1 + r_{D_{t-1}})D_{H_{t-1}} - W_t L_t - Div_t\right)\right).$$

The intermediate producer's:

$$\begin{aligned}
\mathcal{L}_{F,j} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_F^t \Bigg\{ & \frac{Div_{j,t}}{P_t} + \lambda_{1,j,t}\left(\Pi_{j,t} - \Pi_{j,t-1} - \pi_{j,t}(\cdot) + Div_{j,t}\right) \\
& + \lambda_{2,j,t}\left(P_t K_{j,t} - L_{F_{j,t}} - \Pi_{j,t}\right) \\
& + \lambda_{3,j,t}\left(L_{F_{j,t}} - \eta_K P_t K_{j,t}\right) \\
& + \lambda_{4,j,t}\left(K_{j,t} - (1 - \delta)K_{j,t-1} - I_{j,t}\right) \\
& + \lambda_{5,j,t}\left(A_t K_{j,t-1} \alpha L_{j,t}^{1-\alpha} - Y_t\left(\frac{p_{j,t}}{P_t}\right)^{-\varepsilon}\right) \Bigg\}.
\end{aligned}$$

The banker's Lagrangian function is as follows:

$$\mathcal{L}_B = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_B^t \left\{\log(DivB_t) - \log P_t^* + \lambda_{B,t}\left(E_t - E_{t-1} + DivB_t - \pi_t^B\right)\right\}.$$

## Appendix 4

Here we state all equations of the baseline model

$$W_t L_t + Div_t + \left(1 + r_{D_{t-1}}\right) D_{H_{t-1}} = P_t C_t + D_{H_t},$$

$$\sigma_L L_t = \frac{W_t}{P_t C_t},$$

$$\beta \mathbb{E}_t \left[ \frac{v_{t+1}}{v_t} \frac{(1 + r_{D_t}) P_t}{P_{t+1} C_{t+1}} \right] = \frac{1}{C_t},$$

$$Y_t = A_t K_{t-1} \alpha L_t^{1-\alpha},$$
$$K_t = K_{t-1}(1 - \delta) + I_t,$$
$$P_t K_t = L_{F_t} + \Pi_t,$$
$$\Pi_t = \Pi_{t-1} - Div_t + \pi_t,$$

$$\pi_t = P_t Y_t - W_t L_t - P_t \delta K_{t-1} - r_{L_{t-1}} L_{F_{t-1}} - \Omega_t^I - \Omega_t^P + K_{t-1} \Delta P_t,$$

$$\Omega_t^P = \frac{\psi_P}{2} \left( \frac{P_t}{P_{t-1}} - 1 \right)^2 P_t Y_t,$$

$$\Omega_t^I = \frac{\psi_I}{2} \left( \frac{I_t}{I_{t-1}} - 1 \right)^2 P_t I_t,$$

$$\frac{\partial \Omega_t^I}{\partial I_t} = \frac{\psi_I}{2} P_t \left( 1 + 3 \left( \frac{I_t}{I_{t-1}} \right)^2 - 4 \left( \frac{I_t}{I_{t-1}} \right) \right),$$

$$\frac{\partial \Omega_{t+1}^I}{\partial I_t} = -\psi_I P_{t+1} \left( \frac{I_{t+1}}{I_t} \right)^2 \left( \frac{I_{t+1}}{I_t} - 1 \right),$$

$$\frac{\partial \Omega_t^P}{\partial P_t} = \psi_P Y_t \left( \frac{P_t}{P_{t-1}} - 1 \right),$$

$$\frac{\partial \Omega_{t+1}^P}{\partial P_t} = -\psi_P Y_{t+1} \left( \frac{P_{t+1}}{P_t} \right)^2 \left( \frac{P_{t+1}}{P_t} - 1 \right),$$

$$\frac{\partial \Omega_t^P}{\partial L_t} = \frac{(1 - \alpha)}{L_t} \Omega_t^P,$$

$$\frac{\partial \Omega_{t+1}^P}{\partial K_t} = \frac{\alpha}{K_t} \Omega_{t+1}^P,$$

$$\lambda_{1,t} = -\frac{1}{P_t},$$

$$\lambda_{2,t} = -\frac{1}{P_t} + \beta_F \mathbb{E}_t \left[ \frac{1}{P_{t+1}} \right],$$

$$\lambda_{3,t} = -\frac{1}{P_t} + \beta_F \left( 1 + r_{L,t} \right) \mathbb{E}_t \left[ \frac{1}{P_{t+1}} \right],$$

$$\lambda_{4,t} = -\frac{1}{P_t} \frac{\partial \Omega_t^I}{\partial I_t} - \beta_F \mathbb{E}_t \left[ \frac{1}{P_{t+1}} \frac{\partial \Omega_{t+1}^I}{\partial I_t} \right],$$

$$\lambda_{5,t} = \frac{L_t}{(1 - \alpha) P_t Y_t} \left( W_t + \frac{\partial \Omega_t^P}{\partial L_t} \right) - 1,$$

$$Y_t \left( 1 + \varepsilon \lambda_{5,t} \right) = \frac{\partial \Omega_t^P}{\partial P_t} + \beta_F \mathbb{E}_t \left[ \frac{P_t}{P_{t+1}} \frac{\partial \Omega_{t+1}^P}{\partial P_t} \right],$$

$$\left( \eta_K P_t \lambda_{3,t} - P_t \lambda_{2,t} - \lambda_{4,t} \right) = \beta_F \mathbb{E}_t \left[ \alpha \frac{Y_{t+1}}{K_t} \left( 1 + \lambda_{5,t+1} \right) + 1 - \delta - \frac{P_t}{P_{t+1}} \right.$$

$$\left. -\lambda_{4,t+1} (1 - \delta) - \frac{1}{P_{t+1}} \frac{\partial \Omega_{t+1}^P}{\partial K_t} \right],$$

$$\lambda_{3,t}\big(L_{F_t} - \eta_K P_t K_t\big) = 0,$$

$$L_{F_t} = D_{H_t} + F_t + E_t,$$

$$E_t = E_{t-1} - DivB_t + \pi_t^B,$$

$$\pi_t^B = r_{L_{t-1}} L_{F_{t-1}} - r_{D_{t-1}} D_{H_{t-1}} - r_{F_{t-1}} F_{t-1} + \gamma \log\left(\frac{E_{t-1}}{\omega L_{F_{t-1}}} - \mu_{t-1}\right) L_{F_{t-1}},$$

$$r_{F_t} = r_t^*\left(\phi_0 + \phi_1 \frac{F_t}{P_t Y_t}\right),$$

$$\frac{1}{DivB_t} = \beta_B \mathbb{E}_t\left[\frac{1}{DivB_{t+1}}\right]\left(1 + r_{D_t} + \gamma \frac{L_{F_t}}{E_t - \mu_t \omega L_{F_t}}\right),$$

$$r_{L_t} - r_{D_t} = \gamma\left(\frac{E_t}{E_t - \omega \mu_t L_{F_t}} - \log\left(\frac{E_t}{\omega L_{F_t}} - \mu_t\right)\right),$$

$$F_t = P_t Y_t \frac{r_{D_t} - \phi_0 r_t^*}{2\phi_1 r_t^*},$$

$$P_t NX_t = DivB_t + r_{F_{t-1}} F_{t-1} - \Delta F_t,$$

$$NX_t = n_1 P_t - n_2 - n_0 C_t.$$

There are 33 equations and 33 endogenous variables. The exogenous variables are $A_t$, $\mu_t$, $r_t^*$, $\nu_t$.

## Appendix 5

Noting that in the steady-state price and investment adjustment costs, as well as their respective partial derivatives, are equal to zero and normalizing total factor productivity $A$ to unity, we can recursively derive steady-state expressions for model variables

$$r_D = \frac{1}{\beta} - 1,$$

$$\frac{E}{L_F} = \mu\omega + \frac{\gamma}{\dfrac{1}{\beta_B} - \dfrac{1}{\beta}},$$

$$r_L = r_D + \gamma\left(\frac{E/L_F}{E/L_F - \mu\omega} - \log\left(\frac{1}{\omega}\frac{E}{L_F} - \mu\right)\right),$$

$$\frac{F}{PY} = \frac{r_D - \phi_0 r^*}{2\phi_1 r^*},$$

$$r_F = r^*\left(\phi_0 + \phi_1 \frac{F}{PY}\right),$$

$$\frac{Y}{K} = \frac{1}{\alpha}\left(\frac{\varepsilon}{\varepsilon - 1}\right)\left((1 - \eta_K)\left(\frac{1}{\beta_F} - 1\right) + \eta_K r_L + \delta\right),$$

$$\frac{Y}{L} = \left(\frac{Y}{K}\right)^{\alpha/(\alpha-1)},$$

$$\frac{W}{P} = (1 - \alpha)\frac{Y}{L}\left(\frac{\varepsilon - 1}{\varepsilon}\right),$$

$$\frac{L_F}{PY} = \eta_K \left(\frac{Y}{K}\right)^{-1},$$

$$\frac{D_H}{PY} = \left(1 - \frac{E}{L_F}\right)\frac{L_F}{PY} - \frac{F}{PY},$$

$$\frac{C}{Y} = 1 - \delta\frac{K}{Y} - r_L\frac{L_F}{PY} + r_D\frac{D_H}{PY},$$

$$L = \left(\left(\frac{1-\alpha}{\sigma_L}\right)\left(\frac{\varepsilon - 1}{\varepsilon}\right)\left(\frac{Y}{L}\right)^{1-\theta_C}\left(\frac{C}{Y}\right)^{-\theta_C}\right)^{1/(\theta_L + \theta_C)},$$

$$Y = \left(\frac{Y}{L}\right)L.$$

Now that we have the expression for output, we move on to express the price level

$$\frac{\pi^B}{PY} = r_L\frac{L_F}{PY} - r_D\frac{D_H}{PY} - r_F\frac{F}{PY} + \gamma\log\left(\frac{E}{L_F}\frac{1}{\omega} - \mu\right)\frac{L_F}{PY},$$

$$NX = \left(\frac{\pi^B}{PY} + r_F\frac{F}{PY}\right)Y,$$

$$C = \left(\frac{C}{Y}\right)Y,$$

$$P = \left(\frac{n_1}{NX + n_0 C}\right)^{1/n_2}.$$

Utilising the expressions for ratios above, we can obtain the steady-state expressions for the following variables: $L_F$, $E$, $F$, $K$, $W$, $D_H$, and $\pi^B$. We can use these to obtain the rest of the variables

$$\lambda_1 = -\frac{1}{P},$$

$$\lambda_2 = \frac{\beta_F - 1}{P},$$

$$\lambda_3 = \frac{\beta_F(1 + r_L) - 1}{P},$$

$$\lambda_4 = 0,$$

$$\lambda_5 = \frac{WL}{(1 - \alpha)PY} - 1,$$

$$I = \delta K,$$

$$\pi = PY - WL - P\delta K - r_L L_F,$$

$$\Pi = PK - L_F,$$

$$Div = \pi,$$

$$DivB = \pi^B.$$